MACHINERY.

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DESIGN AND CONSTRUCTION OF METAL-WORKING SHOPS—2.

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IN the previous article of this series, the author dwelt at length on the controlling influence of the engineer in the planning of extensive improvements. In order to maintain the personal tone, the following observations, while of general interest, will be addressed to the engineer in charge.

It is highly improbable that a corporation, with the wisdom and caution acquired by successful growth, will expend large sums of money for improvements without having at hand information covering "the existing state of the art." The engineer, therefore, should spend considerable time visiting the best and largest examples of recently built plants for metal-working, and also, from the first moment that extensions are considered, gather together all information possible bearing on the subject from technical papers. It is well to formulate an outline of the essential points affecting, first, the efficiency of the plant; second, the adaptability for systematic extension; third, the expense attending the operation; fourth, the construction of buildings; and fifth, the cost of plant.

The following points are suggested as covering such information as will be of use in planning new shops. Other things

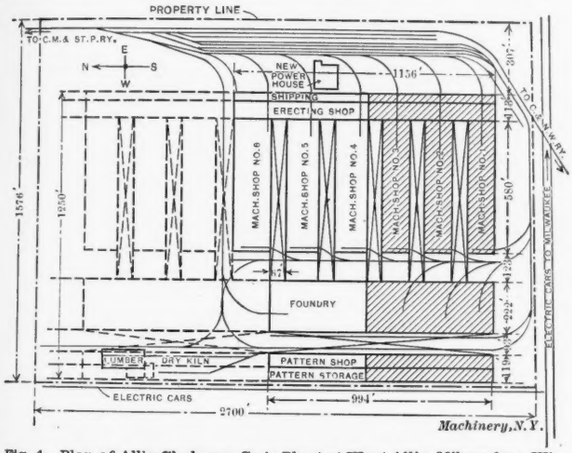

Fig. 4. Plan of Allis-Chalmers Co.'s Plant at West Allis, Milwaukee, Wis.

will suggest themselves if some particular branch of the manufacturing is "lame" in the shops for which improvements are under consideration, as, for instance, the forge shop or power plant, which are often neglected in shops otherwise highly efficient. Under the head of efficiency, look for the adaptability of the buildings to the equipment within them; as to whether or not there is sufficient height and span of cranes over the erecting space, as often provision is not made for increase in size of the product; and in the machine shop space, look at the reservation of space near machines for work in progress, so that expensive machines may not be held up waiting for castings to be brought from some remote part of the works. Such provision well justifies the cost of the additional width of bay required. Then, as to shipping, look out for space and handling facilities that will obviate the use of the valuable productive erecting space for tracks and boxing. The handling of work affects the productive efficiency according to the amount of non-productive time spent by producers in waiting for cranes and getting work on and off machines; therefore, attention should be given to the number of traveling cranes in relation to the floor space served by them, to the use of industrial tracks and column jib-cranes, and to the operating speeds of the various handling apparatus. This question of handling work may perhaps be considered a question of equipment, but it is involved in the arrangement of space and affects the amount of space and dimensions a great deal.

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Under the head of future extension, observe the area of the site in relation to space covered by the buildings, and how the works' system of trackage is planned in connection with the trunk lines of the various railroads serving the city where the site is located. Observe the points that bear on the labor supply; such as homes, street-car facilities, and the proximity to large manufacturing sections from which the better class of workmen can be drawn.

Under expense of operation, study the arrangement of space and the length of haul within the works of the bulk of the material handled, the rapidity of handling, and the course of the product through the works; also the arrangement of trackage, and facilities for storage and unloading which tend to keep down demurrage charges. The type of buildings has also a bearing on the expense factor through the variation of insurance rates. The length and efficiency of power transmission lines, and the efficiency of the power plant and heating apparatus, are large factors in the expense of operation.

The details of building construction, when brought together for comparison, show the trend of the best thought, inasmuch as particular features that may be found in *all* or *nearly all*

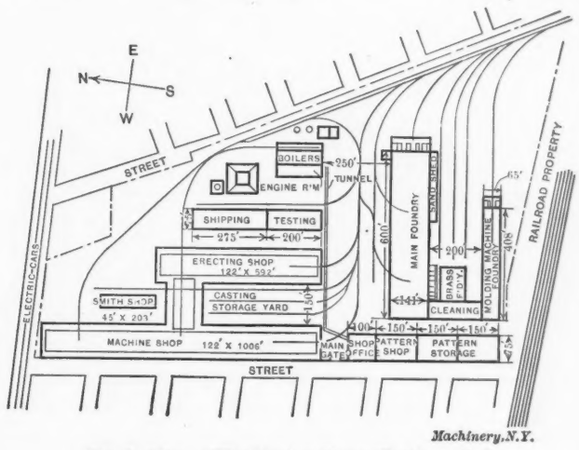

Fig. 5. Plan of Worthington Shops, Harrison, N. J.

of the later plants, and which also conform to the recommended standards of the underwriter's and fire-protective associations, certainly are good examples to follow. The writer has almost come to regard the recommendations of the factory mutual fire insurance companies as axioms, and to judge building construction accordingly. The fact that the fire losses for the past ten years in plants insured in the older factory mutual companies, and conforming to their standards, has been but four cents per hundred dollars annually compared with sixty cents in other properties, seems sufficient justification for this opinion. The framing, walls, roofs, floors, galleries, fire-proofing, and lighting should all be studied, and their relative costs. Railroad shops should not be neglected in one's investigations, as the size of some of the latest shops is such that almost all of the problems that arise in planning any metal-working shop have been handled on a large scale in planning them.

The points outlined above will aid in getting at the meat of many published articles, and in gathering definite facts, rather than general knowledge without a definite application in mind. The following resumé of the leading features of some of the later plants will emphasize the bearing of these points on various factors affecting the planning of new shops.

Study of Recent Plants.

A site for a new plant may be selected from a number of sites by its preponderance of advantages affecting the following heads: Adaptability for future extensions; railroad facili-

ties; labor supply; water supply; cost of foundations; cost of power.

The West Allis plant of the Allis-Chalmers Co. at Milwaukee, Wis., is pre-eminent in meeting the requirements under most of these heads. Fig. 4 shows the general plan. The original buildings are shown by the shaded portion, the recent additions by the full lines, and the possible limits of extensions in conformity with the predetermined plan, by the

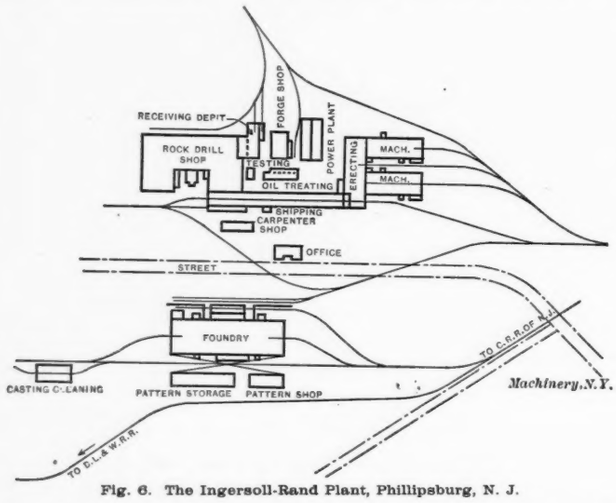

Fig. 6. The Ingersoll-Rand Plant, Phillipsburg, N. J.

dotted lines. The arrangement and type of buildings are such that this layout of extension can be followed even if the nature of the product should be entirely different from the present lines. This plant is served by two railroads, and the activity of the rival freight agents in endeavoring to secure the lion's share of the business naturally tends toward a liberal supply of cars even when there is a general car shortage. As regards the labor supply, Milwaukee is the principal manufacturing city in this section of the country. Locally, the site is in a recently improved community, just outside of the city limits.

TABLE V. COMPARISON OF PLANT ARRANGEMENTS.

	West Allis Works, Plant No. 6.	Worthington Works, Plant No. 7.	Ingersoll-Rand Works, Plant No. 8.
Rectangular space, sq. ft.	1,445,000	1,000,000	1,562,500
Covered by buildings	746,000	450,000	400,000
Percentage covered by buildings	51	45	26
Yard space under cranes	305,000	None	25,000
Percentage	21	None	1.6
Percentage remaining	28	55	72.4
Minimum distance between foundry and machine shops.	123 ft.	250 ft.	560 ft.
Maximum distance between extreme points of foundry and machine shops	1,500 ft.	1,750 ft.	2,000 ft.
Average haul of castings	810 ft.	1,111 ft.	1,280 ft.
Maximum distance of power transmission (electric)	1,500 ft.	1,100 ft.	1,600 ft.
Distance of transmission when ground floor space was 400,000 square feet	600 ft.		

The well lighted and well ventilated shops, together with these other advantages, make the plant attractive to a high class of mechanics. The site chosen was a nearly level field of two hundred acres, and as a good bearing soil lay within a few feet of the surface, very little grading was necessary, and the foundation cost was relatively low. The item of foundation cost as effected by a proposed site is important, as the cost of one foot of foundation in depth will pay for two or more feet of brick wall above the foundation.

Referring to Fig. 4, the great area of yard space served by yard cranes will be noticed, as shown by the diagonal lines between the various buildings, and this space is as effectively used as if under roof; the storing of castings inside the shop long in advance of the time when the machines are ready for them is avoided.

Arrangement of Buildings.

It has previously been stated that the arrangement of departments is one of the major factors affecting shop efficiency, and the facilities for handling materials another. The more effective use of space at the West Allis plant (Fig. 4) compared with the Worthington Works at Harrison, N. J. (Fig. 5), and the Ingersoll-Rand Works at Phillipsburg, N. J. (Fig. 6), is shown by the following: The rectangle formed by the buildings indicated by the dimensions 1,156 feet north and south, and 1,250 feet east and west contains 1,445,000 square feet; the buildings in Fig. 5 are contained in a rectangle 1,550 by 800 feet, and deducting east of the smith shop leaves approximately 1,000,000 square feet. The buildings in Fig. 6 are contained in a rectangle 1,250 by 1,250 equaling 1,562,500

TABLE VI. GENERAL DIMENSIONS AND DESCRIPTION OF RECENTLY BUILT PLANTS.

Building.	Plant No. 6.	Plant No. 7. High.	Plant No. 7. Low.	Plant No. 8.
Erecting Shop—				
Crane-track span	70′	58′	59½′	112′
Crane-track, height	60′	62′		35′
Floor to roof truss	72′6″	72′		44′
Width of building	72′	126′	122′	
Machine Shop.				
Large work—	Nos. 1-2.	Nos. 4-5.		
Width of building	122′	145′	122′	100.
Width of bays	26′-69′-26′	69′-71′	30′-62′-30.	30′-40′-30′
Crane-track span	67′	67′	59½′	38′
Crane-track, height	26′	44′6″	30′	25′
Floor to truss	34′	52′	50′	
Under gallery floor—				
Crane track span	25′6″	38′6″	28′	No galleries.
Crane track, height	13′	17′	13′	
Floor to ceiling	18′	21′3″	15½′	
Gallery Floor—				
Above main floor	21′4″	26′2″	18′4″	
Head-room	14′8″	16′	12′	
Machine Shop.				No galleries.
Small work—	4 Stories.		Galleries in shops.	Saw-tooth roof.
Width of floors	53′ inside		31½′	18 bays 25′ wide.
Head-room—				
1st story	21′4″		15′6″	13′6″-16′6″
2d story	14′2″		12′6″	Ventilating bays run N. and S. 20′ wide, 29′ high. See Fig. 15.
3d story	14′3″		12′6″	
4th story	12′8″			
Roofs	Flat pitch. Center skylights. No monitors. Wood sheathing. Tar and gravel.	Flat pitch. Center skylights. No monitors. Wood sheathing. Composition.		Pitch 1 in 5. Center skylights. Monitors.
Framing	Steel.	Steel.		Steel.
Walls	Brick.	Brick.		Brick.
Pattern Shop.	One story brick. Steel frame fireproofed. Flat pitch concrete roof. Wire-glass windows with metal frames. Fire-doors automatic.			Slow-burning mill construction. Wood floors with asbestos paper between. Plank roof covered with 4-ply slag roofing.
Pattern Storage.	Four stories. Same construction as pattern shop.			Four stories. Pattern shop is a part of this building.
Foundry.	Brick and steel. Roof—Flat pitch, plank covered with tar and gravel.	Brick and steel. Flat pitch.		Brick and steel. Pitch 1 in 5.
Width of building	222 feet	141 feet.		160 feet.
Width of main bay	80 "	60 "		69 "
Crane track span	78 "	58 "		65 "
Crane track, height	28 "			32 "
Floor to roof truss	49 "	38 "		46 "
Side bays	Center skylights. One 68′ wide. Two 32′ wide. Skylights.	Center skylights. Two 40′ wide. Skylights.		Side skylights. Two 46′ wide. Skylights.
Height of charging floor	23 feet.	21 feet.		18 feet.
Sand and supply storage	On sand floor at level of charging floor inside of building.	In lean-to outside of main space.		Outside storage bins.
Cleaning	No separate building.	Large work inside. Small work separate building.		Separate building.
Moulding machine foundry	Part of main foundry.	Separate building, sand-mixing below.		Part of main foundry.

square feet. The ground space covered by buildings within these areas is 746,000 square feet for Fig. 4 or 51 per cent, 450,000 square feet, or 45 per cent for Fig. 5, and 400,000 square feet, or 26 per cent for Fig. 6. Then again, Fig. 4 has 21 per cent of the remaining space within the rectangle under yard cranes, Fig. 5 is without yard cranes, and Fig. 6 has but 25,000 square feet or less than 2 per cent under yard cranes. These percentages with other items pertaining to the handling of materials are compared in Table V.

A visit to the West Allis plant will dispel any doubt, because of the compact arrangement of space, as to there being sufficient yard room. The sectional book-case idea is noticeable in the lay-out of the Ingersoll-Rand plant as well as the West Allis works, and the relation of departments will be unchanged despite additions that may be made.

An advantage peculiar to the layout of wing machine-shops at right angles to the erecting shop with yards between lies in what may be called the side-feed of unfinished materials to the machine-shops. Castings are stored in these yards adjacent to the door nearest the interior point where they will be machined. This side-feed requires the least amount of crane and truck handling and provides the shortest possible inside route to the erecting floor, and eliminates in a measure the well known scene in end feed shops when all of the cranes are tied up at one end while the furthermost crane is getting a large casting for transportation to the other end of the shop.

The future methodical extension of all the departments does not seem to have been considered necessary for Plant No. 7, Fig. 5, as only the smith shop, low erecting shop, and molding machine foundry have lee-way.

These three plants have the problem in common of the economical production of large, medium and small work in next the west wall, the skylight area being approximately 5 per cent of the slant area. The machine bay at right angles to the main bay is 73 feet wide and 34 feet to the roof truss, and the machine bays parallel with the main bay are 44 feet and 35 feet wide and 22 feet to the trusses. The foundry main bay is 75 feet wide and 40 feet to roof truss; the roof is slate on plank and pitched 1 in 6. The lean-to bay is 39 feet wide and 24 feet to the truss, roof slope 1 in 10, and of plank covered with tar and gravel.

The Ball Engine Works, Erie, Pa., is interesting in the comparison of the buildings with those of the Hooven plant. Fig. 16 shows the erecting shop, 200 feet long, 74 feet wide, 44 feet to trusses; roof slope, 1 in 4, of plank covered with slate. The machine shop bays are at right angles to the erecting space and consist of alternate flat and pitch roofs 20 feet wide, forming a unique type of saw-tooth roof. This form of saw-tooth, supplemented as it is by the windows in the walls, has a more pleasing architectural effect than the severely plain type of saw-tooth roof shown in Fig. 17 which represents the erecting shop and machine bays of the Ridgeway Machine Tool Co. at Ridgeway, Pa. These latter shops are without side-wall windows except in the north wall. The roof of Fig. 16 is far superior as regards ventilation on account

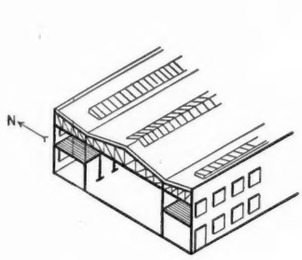

Fig. 7

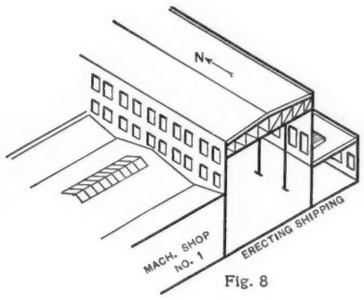

Fig. 8

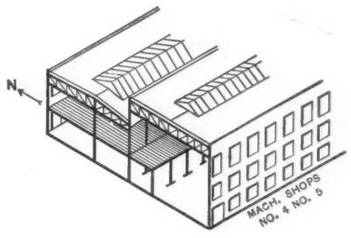

Fig. 9

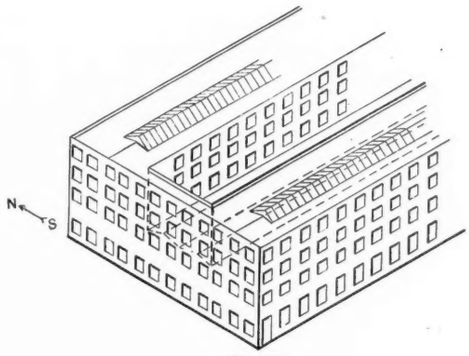

Fig. 10

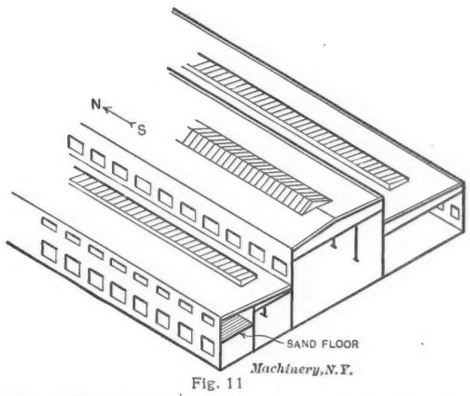

Fig. 11

Fig. 7. Machine Shops Nos. 1 and 2 of the Plant shown in Fig. 4. Fig 8. Erecting and Shipping Department. Fig. 9. Machine Shops Nos. 4 and 5. Fig. 10. Machine Shop No. 6. Fig. 11. Foundry.

large quantities, and the Table VI indicates the manner in which different designers have met the conditions.

The heating of these three plants is through the medium of hot water under forced circulation, the heaters being in series with regular condensers, the vacuum on the engines being broken in proportion to the temperature of the outside atmosphere. The relative areas of departments and the power requirements of these and other large plants will be given later.

The following information is derived mainly from articles in past issues of MACHINERY. The Hooven-Owens & Rentschler Co. works at Hamilton, Ohio, was described in the January, 1904, number. This firm builds vertical and horizontal Corliss engines. The plant is exceptionally well equipped as the maximum size of work is limited only by the machine tools, of which the 20 x 20-foot boring-mill and a planer 14 x 12 x 35 foot traverse are the largest. The shops are of brick and steel, and the lighting and ventilation are good. The main erecting bay is 75 feet wide and 57 feet from floor to lower chord of roof truss. The main machine bay has the same dimensions. The roofs of the two bays are of one-sixth pitch, of plank and slate, and with skylights except on the slope of the opportunity for using movable sash in the vertical frames; and the elimination of gutters and consequent freedom from troubles, caused by melting and freezing of snow, common to the cheaper forms of the regular saw-tooth, is a strong point in favor of this modified type. The crane tracks project into the erecting space in both the shops shown in the two figures.

The B. F. Sturtevant Shops.

The new B. F. Sturtevant plant at Hyde Park, Mass., has many interesting features in the composite type of buildings. New England mill construction forms the base and is modified by the use of steel interior columns for the first story, a 20-foot column spacing, steel main girders and 12 x 16-inch wood floor beams on 4-foot centers for gallery floors, and by the transverse saw-tooth skylights over the high erecting floor and inner portions of the galleries. The erecting bay is 40 feet wide and 30 feet from floor to truss. The galleries on either side are 40 feet wide and have 15 feet head-room under and over the gallery floor. The ground floor is of 3-inch hemlock on tar concrete; the gallery floor for 250-pound load is of 2½-inch hard pine with 1-inch maple top floor, and of 2-inch pine and 1-inch maple for 200-pound load. The roofs

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are ½-inch pitch, 3-inch hard pine planking covered with tar and gravel. There are no wall columns as the walls of brick are 20 inches thick to the gallery floor and 16 inches thick from there to the roof.

The Jones & Lamson Shop.

An excellent example of economical fire-proof construction is afforded by the machine shop of the Jones & Lamson Company at Springfield, Vt. The product of this shop is the well-known flat turret lathe. The building is three stories high, 150 feet long, 75 feet wide, with 14 feet headroom for first floor, 14 feet for second floor, and 11 feet for the third or top floor. A monitor 25 feet wide assists in lighting this floor. About 60 per cent of the wall area is glass, which is the same percentage as the window area of the new Pratt & Whitney machine shop at Hartford. The frame is of steel fire-proofed with concrete, floors and roof are of reinforced concrete, and the curtain walls are of brick.

The Pencoyd Works of the American Bridge Co.

This shop is remarkable for its massive construction as evidenced by the loads for which the gallery floors are designed: the first gallery for 500 pounds per square foot, and the second for 300 pounds per square foot. The central bay is 60 feet wide and the gallery bays 25 feet wide. Concrete is used for walls and extends from web to web of the columns. The window area is 60 per cent of the wall area, and all but the lower sash are glazed with ribbed glass. The headroom under the first gallery is 13 feet, under the second, 12 feet, and 11 feet under the roof. The crane arrangements are most unique. Over the 25-ton crane of 56-foot span in the main bay are two 10-ton cranes of 30-foot span running parallel, the trucks of these cranes away from the columns running on tracks supported from the roof trusses. Under each gallery are two parallel runways suspended from the main floor girders and on these runways are electrically operated jib cranes with 5-foot radius arms. These cranes pick up work from trucks in the gangways and swing it over into the machines. Tar concrete is used under the wood block top floor for the first story under the gallery, the tar being used for its preservative effect on the wood.

Pratt & Whitney Shop.

A shop that is representative of many of the recently constructed New England factory buildings for light and medium work is that of the Pratt & Whitney Company at Hartford, Conn. It is an extremely rigid building with brick walls having about 60 per cent window area, steel frame, and concrete floors with the concrete of the floor slab-haunched down to the lower flange of the supporting I-beams, thereby fireproofing them partly and adding about 50 per cent to their strength.

The roof is nearly flat, of plank covered with tar and gravel roofing. Top floors are of clear 1⅛-inch maple laid on sleepers which are embedded in the concrete. The ground floor consists of 3 inches of concrete, then a damp-proof course of tarred felt, then 9 inches of concrete in which are embedded the 4 x 4-inch sleepers as in the upper floors, and between the concrete and maple there is a stratum of asphalt composition applied hot, thus giving the wood flooring a solid bearing.

The building is very rigid, as the steel work is designed sufficiently strong for an additional story. It is a five-story L-shaped building, one wing being 65 feet wide and the other 75 feet wide, with a double row of interior columns giving a center passage-way 25 feet wide for cranes. The first story has a clear headroom of 18 feet 4 inches and all of the other floors have a headroom of 13 feet 4 inches (considerably more than in most other multi-storied shops), and as the windows come up to the under side of the floors the lighting is excellent. A comparison of this shop with a single-story saw-tooth shop will be given later. As the benches, offices, and tool-rooms are next the walls, and sprinklers are installed, the noticeable absence of wooden cupboards and other combustibles near the interior columns will lead an unbiased observer, I am sure, to pronounce this shop sufficiently fireproof to compare with, and in details to be of a higher class than, a reinforced concrete structure.

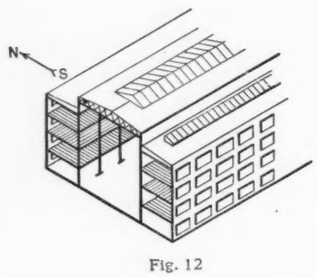

Fig. 12

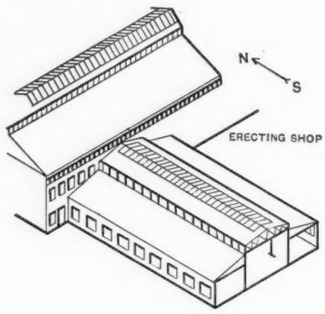

Fig. 13

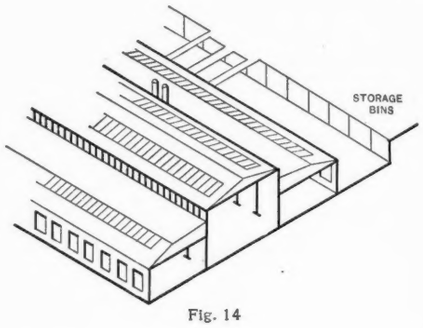

Fig. 14

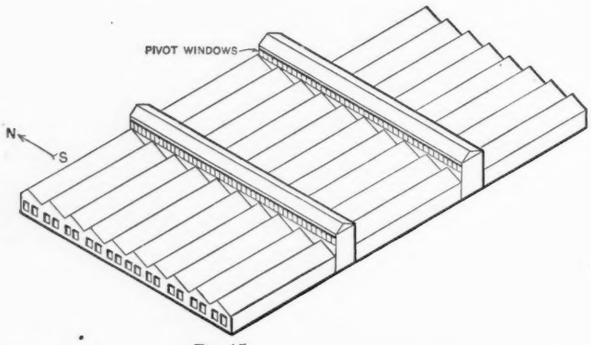

Fig. 15

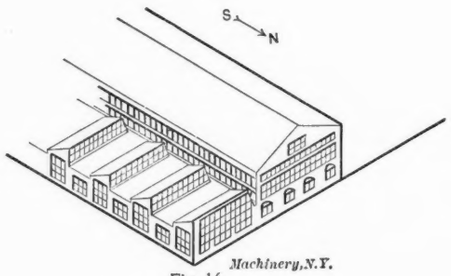

Fig. 16

Fig. 12. High Erecting Shop of Plant shown in Fig. 5. Fig. 13. Machine Shop of Plant shown in Plan in Fig. 6. Fig. 14. Foundry of same Plant. Fig. 15. Machine Shop, Ingersoll-Rand Plant. Fig. 16. Modified Saw-tooth Construction, Ball Engine Co., Erie, Pa.

The foundry is situated across the tracks of the New York, New Haven & Hartford Railroad, and is connected with the machine shops by a concrete tunnel which has the double function of affording a passageway protected from the weather for castings and for the distribution of heat, light, and power between the various buildings.

Hoefer Manufacturing Company.

The machine shop of the Hoefer Mfg. Co., described in MACHINERY December, 1905, is three stories in height, of modified mill construction with wooden columns spaced on 20-foot centers each way, and with wood floor beams. The floors consist of a ⅞-inch maple top floor laid on 3-inch yellow pine under planking; the walls are of brick, 17 inches thick for the first story and 13 inches thick for the two upper stories. The cost is given as $22,000, or a little less than $1.00 per square foot of floor space.

Colburn Machine Tool Co.'s Machine Shop, Franklin, Pa.

This shop is typical of many of the medium-sized plants making machine tools and requiring traveling cranes. The shop is of brick and steel with a slate roof laid on plank. The main bay is 37 feet wide and 31 feet to the roof truss; the side bays are each 30 feet wide and 14 feet to the trusses. The glass surface is about 65 per cent of the area of the side walls. This shop was described in MACHINERY, February, 1906, and details and specifications were also given. The machine shop portion of Fig. 13 illustrates this type of shop.

United Shoe Machinery Co.'s Plant, Beverly, Mass.

The designers and owners of this plant have adopted a purely reinforced concrete construction. The floor space covered is about 17 acres, and the floors, roofs and columns of all buildings are of concrete. About 90 per cent of the entire wall area is of glass. There should be some great advantages in this exceptionally large glass surface to justify the greatly increased cost of heating, but these advantages are too deeply hidden to be excavated by the author. Sprinklers are installed only where combustibles are used or stored, and no insurance is carried.

The Aiken Roof Type of One-story Shop.

This peculiar type of roof construction is shown in Fig. 18. The advantages possessed by this form over the ordinary saw-tooth roof for buildings of very large areas are found in low first cost and maintenance. The lighting is not so uniform, but is very good. The shops of the Standard Steel Car Company at Butler, Pa., are of this type, the main building being 400 feet by 1,612 feet. The National Malleable Castings Company shop of this type is 225 feet wide and 750 feet long. In this type of roof, sections are almost flat, the high sections being carried on the upper chord members and the lower sections attached to the bottom chord members of the trusses. The writer believes that even the strongest advocates of saw-tooth construction will admit the lower cost and superior natural ventilation of this type, at least on single buildings of large area.

Multi-storied and Saw-tooth Roof Shops Compared.

The Pratt & Whitney machine shop compared with a saw-tooth shop of equivalent floor area (125,000 square feet) has better natural ventilation, is cooler in summer, has 25,000 square feet of the simplest form of roof against 125,000 square feet of skylights, and has 80 per cent less underground piping to maintain. Heat, light, and power distribution is more economical both in first cost and in transmission losses. The greatest distance that a truck-load of material would traverse on elevator and floor from the receiving point in one corner to the extreme corner of the upper floor is 300 feet against 450 feet from corner to corner of a one-storied structure.

As regards lighting, the saw-tooth shop undoubtedly possesses an advantage in the better diffusion of light, and consequently the strain on the eyes is greatly minimized. This advantage may be offset in a degree by the use of ribbed glass in the upper sash or windows and by the necessary window shades on east and south sides of a five-story building. The writer has yet to find that the productive efficiency in any saw-tooth shop is greater than in the many two or more storied shops in the manufacturing cities throughout the country. The writer recently has had experience in handling a maze of fine cotton yarns in a side-lighted shop and can fully appreciate the necessity of a soft, even light for textile work, but cannot see the necessity for better lighting in machine shops than can be obtained by side lighting.

Comparative Cost.

The cost of saw-tooth shops may be 40 to 50 cents less per square foot of floor space than the high-class Pratt & Whitney shop described, but not less than a shop of slow-burning mill construction. The cause of this 40 or 50 cents difference per square foot is partly shown by the Table VII. These items, of course, do not make up the entire cost. The column *A* is for a high-class five-story machine shop for light and medium work and with a floor space of 125,000 square feet, gravel roof on plank sheathing on wooden purlins supported by steel roof beams. Column *B* is a saw-tooth shop of 125,000 square feet, roof slopes covered with slate.

Much of this apparent saving on buildings may be offset by the extra cost of sewers, piping and wiring, so that a fair comparison of cost cannot be made except for shops for manufacturing like products, and ready for operation.

Reinforced Concrete as a Building Material.

For underground work reinforced concrete is unsurpassed, for instance for tunnels, foundations, retaining walls, and vaults. Pattern shops and pattern storage buildings should be of real fire-proof construction and therefore concrete is an ideal material for their construction. Concerns making light work are as well housed in one type of construction as another, but for machine shops and foundries necessitating high roofs and wide spans, brick and steel construction is better suited. Despite their strongly presented claims of low cost, leading concrete construction companies in New England and the Central West, in 1906, could not meet the steel companies on cost and time of erection, but undoubtedly concrete construction methods have been very much perfected since then. As the allowable stress per square inch of section in columns of reinforced concrete and steel is in the ratio of one

TABLE VII. COST IN CENTS PER SQUARE FOOT OF FLOOR AREA.

	A	*B*
Land—based on $435 per acre	0.2	1.0
Floors	26.0	22.0
Steel work	65.0	16.0
Walls and foundations	31.0	8.4
Roofs	3.6	40.0
	125.8	87.4

to thirteen, a concrete column occupies twice as much space as a steel column, and by casting broader shadows affects the lighting adversely. The writer is loth to believe that concrete should be adopted as the sole material of construction for large plants. As to cost, Mr. Leonard C. Wason writing in the *Engineering Magazine*, June, 1907, states that reinforced concrete construction will cost 10 to 25 per cent more than mill construction, and 20 to 30 per cent less than fire-proofed steel frame buildings. On account of the great variation of bids on reinforced concrete construction, the writer is unable to give reliable information on cost.

Conclusions.

The engineer before commencing work on tentative plans should visit the West Allis plant, even if he never investigates another large works, as he will find that the problems here have been well thought out and logically handled. It will be difficult to find another plant (having so few buildings) capable of turning out a million dollars' worth of work per month within a year after the buildings were completed. The arrangement of space is most excellent, the work is handled economically and expeditiously, the power transmission is economical, and the interior equipment is in keeping with the high class character of the buildings.

For light work, not requiring traveling cranes to serve many of the machine tools, a three-, four-, or five-storied shop with a light court, as shown in Fig. 10, is recommended where compactness of plant is desired or necessitated through lack of ground space or high cost of land.

Mill construction is cheapest for multi-storied shops, and if built to comply with the rules of the factory mutual companies will cost from $1.00 to $1.10 per square foot of floor area. Steel frame construction, not fire-proofed, will cost from $1.40 to $1.60 per square foot, and reinforced concrete will cost from $1.30 to $1.50 per square foot. If the nature of the contents is combustible, automatic sprinklers should be provided, and the insurance rate will be from 20 to 35 cents per $100 per annum on either of the three classes of buildings. Corrugated iron or steel covered buildings are naturally eliminated from consideration for these buildings, because they are not sufficiently warm or permanent except at a high cost of maintenance.

For light and medium work, saw-tooth single-story shops of 40,000 square feet area and an average height of 25 feet can be built for approximately $1 per square foot, but one must be content with a severely plain building, forbidding in appearance.

For medium and heavy machining, or for light and medium machining and erecting, the gallery type shown in Figs. 7, 9,

and 12, is common to most large plants. For building machines up to 15 tons weight the type of building shown in Fig. 13 houses all departments of many plants of 25,000 to 50,000 square feet of floor space. For heavy work, demanding separate machine and erecting shops, the best results are obtained when the machine shops are at right angles to the erecting shop with the cranes projecting into erecting space as in Figs. 8, 13, 16, and 17.

Very high shops of wide span, and with galleries, are uniformly of brick and steel and cost from $1.60 to $2.00 per square foot according to the crane capacity and the gallery floor loads for which the buildings are designed.

Pattern storage buildings are generally 2, 3, or 4 stories in height with fire-walls dividing the space into compartments. Slow-burning mill construction, fire-proofed steel, and concrete are all used, the wooden construction leading; as in all such buildings, automatic sprinklers are the main reliance for the protection of the contents, and given that they protect

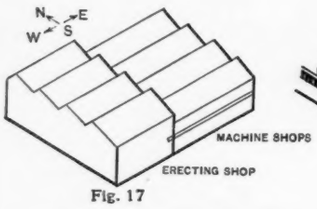

Fig. 17

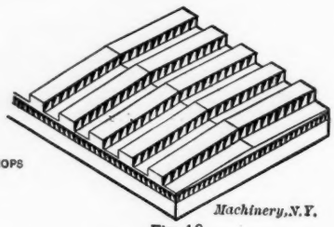

Fig. 18

Fig. 17. Plain Saw-tooth Roof. Fig. 18. Alken Roof.

the contents they will protect the buildings. The writer believes that concrete with metal window frames and wire-glass windows will be the standard construction in the future. In that event no insurance need be carried on the buildings. One very important thing should be remembered in designing pattern storage buildings and that is to design the shelving and racks first, and then determine the window spacing and column spacing.

Another thing that has been impressed on the writer's mind very strongly is to avoid outside down-spouts. This is best accomplished by extending the walls above the roof in the "parapet wall construction" recommended by the insurance companies, at the same time securing a more finished appearance. The down-spouts should have copper wire strainers at least 10 inches high and saddles should be built against the parapet avoiding sharp bends in the roofing felt, and the counterflashing should be built into the brickwork. Down-spouts inside will not freeze, and may be of galvanized iron to within about eight feet of the floor, where they should enter heavy cast-iron piping which should continue to the horizontal drains. The writer has seen, during the past winter, gangs of men with steam hose and fires, engaged in almost futile attempts to thaw out the outside spouts around a large plant.

Roofs of large areas generally require a great deal of attention, and the roofs giving the least trouble are of very flat pitch and covered with tar and gravel or with tar and slag.

Floors in single-story shops are now mostly laid on concrete with a coating of coal tar between the concrete and the planking, and maple top floors are laid on the under planking to give a hard wearing surface and to facilitate repairs. Monolithic concrete floors are fast superseding other kinds for galleries and upper floors, as they add much to the rigidity of a building and can be built to stand heavy loads at a low cost.

Books that are most in demand for information pertaining to the design and construction of shops are: Cambria Steel Company's, Jones & Laughlin's or Carnegie Steel Co.'s handbook, Kidder's "Architects' and Builders' Handbook," and Ketchum's "Mill Buildings."

The preceding matter throughout is written with the dominant idea in mind that the difference between cost and selling price is the principal object in manufacturing, and the writer has endeavored to present principally the points affecting this difference, rather than those tending toward artistic perfection.

DIAGRAMS FOR DESIGNING SPIRAL GEARS.*

FRANCIS J. BOSTOCK.†

Great difficulties are usually experienced in designing spiral gears, and these difficulties are greatly accentuated when one has to design them for two shafts whose center distance cannot be altered to suit the gears, and also when the angle between the shafts is not a right angle, and the speed ratio is not equal. The general practice is to work out the gears by lengthy mathematics, and should the answer not come out as desired, then a new trial is made, varying either one or the other factor, until the angles and diameters are correct. This method of "cut-and-try" entails a great deal of work and waste of time. The following method, together with the diagrams used with it, will remove some of the difficulties, and enable one to arrive at the data required in a very short time. The method adopted is graphical, but the results may be checked by simple figuring.

As the pitch diameter, spiral angle, and circular pitch are interdependent, they cannot be considered as a starting point in solving the problem, because they are not known. The starting point, therefore, must be the speed ratio, and some idea of the strength required, together with the center distance. These factors, as a rule, can easily be ascertained. As it is common usage to employ ordinary spur gear cutters of regular diametral pitches for cutting spiral gears, the normal pitch, or distance from one tooth to the next, measured at right angles to the tooth, must be the same as the pitch of a spur gear for which the cutter to be used is intended; therefore, the corresponding diametral pitch and the speed ratio must be the initial data, all others being obtained afterwards.

Three diagrams are given for the graphical solution of spiral gears. The diagram in Fig. 1 shows the relation between the quotient of number of teeth ÷ diametral pitch, spiral angles, and pitch diameters. The quotient $\frac{\text{number of teeth}}{\text{diametral pitch}}$ is commonly termed "equivalent diameter," and will be so referred to in the following. The diagram in Fig. 2 shows the relation between the diametral pitch, the number of teeth, and the equivalent diameter. Finally, the diagram in Fig. 3 shows the relation between the pitch diameter, the spiral angle, and the lead of the helix. We will now proceed to give some typical examples illustrating the use of the diagrams.

Example 1. Given a gear having 24 teeth, 6 diametral pitch, and a spiral angle of 40 degrees. Find the pitch diameter.

First obtain the value of the ratio, number of teeth ÷ diametral pitch, which, in this case, can be obtained without referring to diagram Fig. 2, being simply $24 \div 6 = 4$. Locate 4 on the horizontal line in diagram Fig. 1, and project vertically until the line from figure 4 intersects the line for 40 degrees spiral angle. Then follow the circular arc from this point, either to the right or downward, reading off 5.22 on the corresponding scale, this being the pitch diameter. Should the diameter be required accurately, we can figure it by the formula

$$\text{Pitch diameter} = \frac{\text{No. of teeth}}{\text{Diametral pitch}} \times \frac{1}{\cos \text{ spiral angle}}$$

$$= 4 \times \frac{1}{\cos 40 \text{ deg.}} = 5.222 \text{ inches.}$$

This also gives a check of the result obtained by means of the diagram. The lead of the helix is now obtained from Fig. 3, by projecting the pitch diameter 5.22 horizontally to the radial line for the spiral angle, and then, following the vertical line to the lead scale at the bottom of the diagram, we find, in this case, a lead of 19.6 inches. Of course, the outside diameter of the blank would be $5.222 + 2 \times 1/6 = 5.555$ inches, which is the pitch diameter + 2 times the addendum.

Example 2. Required two gears which are to be equal in all respects, the diametral pitch being 8, and the centers to be approximately 4 inches apart.

As the centers are not fixed, the gears in this case may be

* For additional information on this and kindred subjects, see the article published in the April, 1908, issue of MACHINERY on the "Derivation of Formula for Determining Spur Gear Cutter Number for Spiral Gears," and other articles there referred to.

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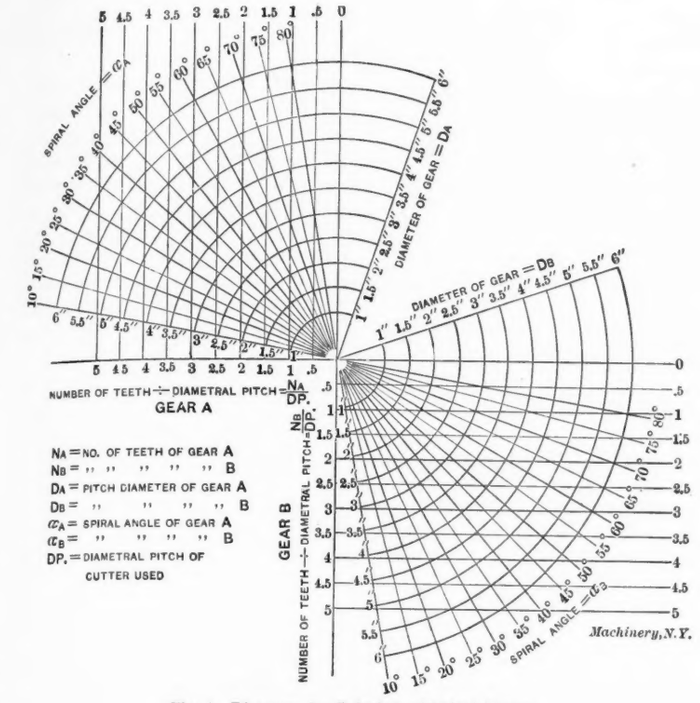
SPIRAL ANGLE = α_A
DIAMETER OF GEAR = D_A
DIAMETER OF GEAR = D_B
NUMBER OF TEETH ÷ DIAMETRAL PITCH = $\frac{N_A}{DP}$
GEAR A
$\frac{N_B}{DP}$ = NUMBER OF TEETH ÷ DIAMETRAL PITCH
GEAR B
N_A = NO. OF TEETH OF GEAR A
N_B = " " " " B
D_A = PITCH DIAMETER OF GEAR A
D_B = " " " " B
α_A = SPIRAL ANGLE OF GEAR A
α_B = " " " " B
DP = DIAMETRAL PITCH OF CUTTER USED
SPIRAL ANGLE = α_B
Machinery, N.Y.

Fig. 1. Diagram for Solution of Spiral Gears.

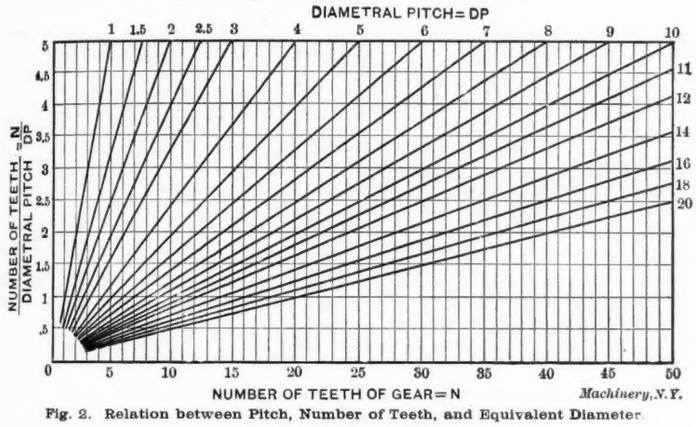

Fig. 2. Relation between Pitch, Number of Teeth, and Equivalent Diameter.

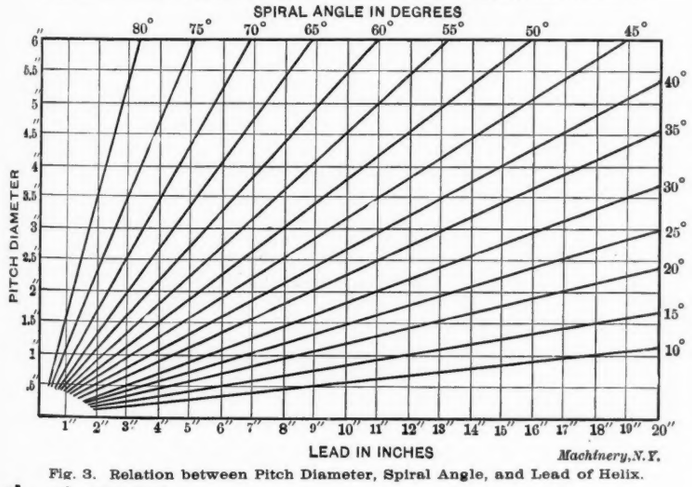

Fig. 3. Relation between Pitch Diameter, Spiral Angle, and Lead of Helix.

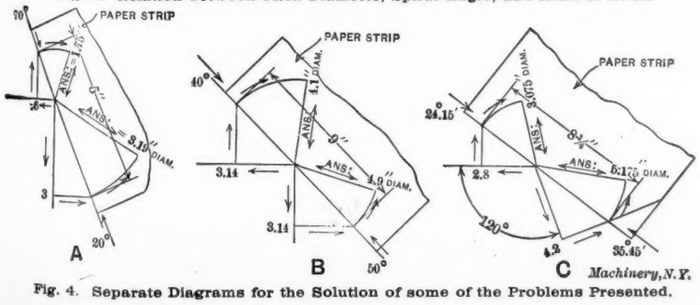

Fig. 4. Separate Diagrams for the Solution of some of the Problems Presented.

made with 45 degrees spiral angle, and the center distance may be slightly adjusted to suit the pitch diameters. Referring to Fig. 1, follow the circular arc from diameter of gear = 4 inches, until it intersects the radial line for 45 degrees spiral angle; then follow the vertical line down to the scale of the ratio between the number of teeth and diametral pitch, which is found to be 2.82. Then, from Fig. 2, we find that with this ratio and 8 diametral pitch, the number of teeth is not a whole number, but the nearest number is 23, giving a ratio of 2.875 instead of 2.82, which, by reversing the process and referring to diagram Fig. 1, gives a pitch diameter of 4.07 inches. These results may be checked as follows

$$\text{Pitch diameter} = \frac{\text{No. of teeth}}{\text{Diametral pitch}} \times \frac{1}{\cos 45 \text{ deg.}}$$

$$= 2.875 \times \frac{1}{0.707} = 4.07 \text{ inches.}$$

The outside diameter is $4.07 + 2 \times 0.125 = 4.32$. The lead, as obtained from diagram Fig. 3, in the same way as in Example 1, is 12.8 inches.

Example 3. Required a pair of spiral gears having a normal pitch corresponding to 10 diametral pitch, having a given center distance of 2½ inches approximately, the sum of the spiral angles being 90 degrees, and the speed ratio equal to 5 to 1.

In this case both portions of diagram Fig. 1 are used, the upper part being employed for one gear and the lower part for the other, the easiest way being to get a strip of paper with two lines marked on its edge 5 inches (twice the center distance) apart, drawn to the same scale as the diagram. Move this strip of paper on the diagram (so that the edge of the strip passes through the center), as indicated at *A*, Fig. 4, until the lines marked coincide with points where the ratio of the equivalent diameters equals 5 ÷ 1, and then determine from Fig. 2 that these diameters also give whole numbers of teeth with 10 diametral pitch. We find that 0.5 and 2.5 at 78 degrees and 12 degrees are two such positions, and also 0.6 and 3.0 at 70 degrees and 20 degrees. If we use the latter values, we will have 6 teeth and 30 teeth at 70 and 20 degrees angle, respectively. The exact diameters can now be determined, as in our previous problem, and are 1.75 and 3.19 inches, respectively, the outside diameters being 0.2 inch larger, or 1.95 and 3.39 inches, respectively. This gives the center distance 2.47. These values can now be figured from the formulas as before, and the leads obtained.

Example 4. Required a pair of spiral gears, having a fixed center distance of 4.5 inches, running at equal speeds, the diametral pitch being 7.

The method of procedure is similar to that of the last example, using a strip of paper having a distance of 9 inches marked on the edge in the proper scale, as indicated at *B* in Fig. 4. At about 40 degrees spiral angle we find in Fig. 1 the ratio of number of teeth to diametral pitch to equal 3.14. This ratio is adjusted on diagram Fig. 2, as previously shown, so as to enable one to get a whole number of teeth with 7 diametral pitch, this number being in this case 22. The ratio is then 3.143, and following from this in Fig. 1 to the 40-degree line, one obtains a pitch diameter of about 4.1 inches for one gear, and at 50 degrees, about 4.9 inches for the other. The spiral angles should now be carefully checked mathematically as follows:

cos spiral angle (first gear)

$$= 3.143 \times \frac{1}{4.1} = 0.766; \quad \text{spiral angle} = 40 \text{ deg.}$$

cos spiral angle (second gear)

$$= 3.143 \times \frac{1}{4.9} = 0.642;$$

spiral angle = 50 deg., nearly.

Now obtain the leads from diagram Fig. 3 in the same way as before, giving the leads of the gears 15.4 and 12.9 inches, respectively.

Example 5. Required a pair of spiral gears, the axes of which are at an angle of 120 degrees; center distance, 4.125; the ratio of equivalent diameters should be as 2 to 3, and the diametral pitch 5.

We require first of all two numbers representing the equivalent diameters, these two numbers bearing the ratio to each other of 2 to 3, and giving a whole number of teeth with 5 diametral pitch. These two numbers, when projected onto two spiral angle lines in a diagram made up as in Fig. 1, the sum of the angles of which lines equals 120 or 60 degrees, give two diameters whose sum equals the center distance multiplied by 2, or 8.25. In this case we cannot use both parts of the diagram Fig. 1, as it is made up for shafts at 90 degrees angle, and for this reason we must take the two readings from the same part of the diagram. The ratios 3 and 4.5 at 30 degrees give corresponding diameters of 3.5 and 5.2, the sum being 8.7. The ratios 2.8 and 4.2 giving 14 and 21 teeth at 25 and 35 degrees, respectively, have diameters of 3.1 and 5.15 (equals 8.25). From this we see that we can use 14 and 21 teeth and the ratios 2.8 and 4.2. The diameters and spiral angles can now be obtained graphically, and more accurately in this manner:

Draw two radial lines, as shown at *C* in Fig. 4, at 120 degrees angle, on a separate piece of paper, and lay off on these to some scale the equivalent diameters, marking the end points 2.8 and 4.2 as shown at *C*, Fig. 4. From these points draw lines at right angles to the radial lines. It is now necesssary to find the position of a line 8.25 inches long, terminating upon these perpendicular lines, and passing through the center. A strip of paper is used in the same manner as before, and upon careful measuring of the respective distances from the center to the lines, one obtains the distances 3.075 and 5.175 inches, which represent the respective diameters, the sum being 8.25. The spiral angle is obtained by measuring or calculating as follows:

$$\cos \text{ spiral angle of first gear} = 2.8 \times \frac{1}{3.075} = 0.910;$$

$$\text{spiral angle} = 24 \text{ deg. } 15 \text{ min.}$$

$$\cos \text{ spiral angle of second gear} = 4.2 \times \frac{1}{5.175} = 0.812;$$

$$\text{spiral angle} = 35 \text{ deg. } 45 \text{ min.}$$

The above examples will show the careful student the manner of working out each kind of gear required, and if the directions are properly followed, this method will be found to be a great time-saver. It may be mentioned that it is advisable to keep the spiral angle as nearly equal in the two gears as possible in order to obtain the greatest efficiency of transmission. It should be noted that when diagrams of this type are to be used for practical calculation of spiral gears, they should be laid out in much larger scale than that shown in the engravings, and it would be advisable to lay out radial lines in Fig. 1 for every degree, and vertical and horizontal lines for every tenth of an inch, and circular arcs for equally fine subdivisions. The same is true of the diagrams in Figs. 2 and 3. In Fig. 2, horizontal lines should be laid out for every tenth of an inch, and vertical lines should be laid out for all whole numbers of teeth. In Fig. 3, the horizontal lines should be laid out for every tenth of an inch, vertical lines for at least every 0.2 of an inch, and radial lines for every degree. This diagram should also be laid out so that leads over 20 inches may be read off, as well as those below this figure.

* * *

Some manufacturing concerns, because of general excellence of product in years gone by, have acquired so great a reputation that they have capitalized their reputation, as it were, using the name to bolster up an output that no longer has superlative merit. So marked is this condition with certain concerns to-day that one whose conversation is marked by greater forcibleness than elegance, remarks: "So-and-so's capitalization of good will and mechanical excellence has a h—— of a lot of water in it."

INSTRUMENTS FOR MEASURING TEMPERATURES.

In an article in *The Engineering Review*, September, 1907, entitled "Practical Pyrometry," the author gives a comparative table of the various types of thermometers and pyrometers in use, explaining the general principles upon which each depends for its working, and stating the limits of temperature between which each type may be used. This table, particularly valuable on account of the concise form in which the information it contains has been put, is reproduced below. At the present time pyrometry is becoming an important subject in industrial life, and is not any longer confined to the scientific laboratory only. It would be difficult to mention many industrial operations that do not involve, during some stage or other, an accurate measurement of temperature. To the engineer, power station manager, foundry operator, metallurgist, and, last but not least, the tool hardener, particularly when he deals with high-speed steel, the judgment of temperature has become of the first importance, as upon it depends the maintenance of efficiency in the highest possible degree, or the perfection of the material under treatment. Guess-work—concomitant with costliness—is now being gradually replaced by scientific thermometry, and manufacturers are realizing the assistance that the physicist is capable of affording them in the vital matter of accurate high temperature measurement.

TYPES OF THERMOMETERS IN GENERAL USE.

Class.	General Characteristics of Action.	Type.	Range in degrees Fahrenheit over which they can be used.
Expansion	Change in volume or length of a body with temperature.	Gas	32 to 1800
		Mercury, Jena glass and nitrogen	—40 to 900
		Glass and spirit or petrol	—350 to +100
		Unequal expansion of metal rods	32 to 900
		Contraction of porcelain	32 to 3250
Transpiration and Viscosity	Flow of gases through capillary tubes or small apertures.	The Uehling	32 to 2900
Thermo-electric	Electromotive force developed by the difference in temperature of two thermo-electric junctions.	Galvanometric	32 to 2900
		Potentiometric	32 to 2900
Electric Resistance	Increase in electric resistance of a wire with temperature.	Direct reading on indicator or bridge and galvanometer	32 to 2200
Radiation	Heat radiated by hot bodies.	Thermo-couple in focus of mirror	32 to 18,000
		Bolometer	32 to 18,000
Optical	Change in brightness or in wavelength of the light emitted.	Photometric comparison	32 to 3600
		Incandescent filament in telescope	32 to 3600
		Nicol with quartz plate and analyzer	32 to 3600
Calorimetric	Specific heat of a body raised to a high temperature.	Copper or platinum ball with water vessel	32 to 2700
Fusion	Unequal fusibility of various metals or earthenware blocks.	Alloys of various fusibilities	32 to 3600

THE DESIGN OF JIB CRANES.*

R. W. VALLS.†

R. W. Valls.‡

Among the various types of jib cranes employed for different services in the industrial field, the simple underbraced type is most common, and has been selected for analysis in this article. In the investigation, the method of design, and all the possible stresses to which this type of crane may be subjected, are considered. The treatise may appear somewhat lengthy for such a simple machine, and although some of the stresses discussed are frequently disregarded in actual practice because of the employment of large factors of safety, yet all stresses should be investigated and provision made for them, especially in cranes of abnormal capacities or proportions, or both, which are frequently met with in practice.

As has often been said, sound judgment is a requisite of a successful designer. No precise rules can ever be formulated to cover all cases as they arise in practice, and the judgment of the designer is called upon repeatedly to decide the correct proceeding where there is no precedent.

The following discussion is of a typical crane, and is treated from a theoretical as well as a commercial standpoint, such as would be followed in the engineering office of a manufacturing company.

The type considered consists essentially of a structure in which *GF*, a mast, rests on a foundation (see Fig. 1), and is supported at the top by a suitable connection. *AE* is a member secured to the mast, and supported at *D* by a strut *DC*, which is bolted or riveted to a gusset plate on the member and mast, or connected to these members either with angles or castings as in Fig. 4. Let us first investigate the stresses produced in these members composing the frame, by the external forces acting on the crane. The member *AE*, commonly called the jib, is subjected to stresses produced by the loads concentrated at the wheels of the trolley, and the weight of the members themselves, which stresses we will proceed to find. The trolley carrying the load is supported by four wheels traveling the length of the jib and producing the loads p, p, placed at a distance d from each other. The constant distance d is known as the wheel base. These wheel loads p, p are equal to the sum of the net load to be lifted, P, plus the weight of the trolley, ropes and bottom block, divided by the number of wheels supporting trolley, usually four.

The jib is considered as a beam supported at the joints *A* and *D*, having a cantilever end *DE*, and subjected to axial tensile, eccentric tensile, eccentric compressive, and flexural stresses. The length of the cantilever end from *D* to center line of load, when the load is at extreme outer end of the jib, is frequently made about one-fourth the distance between supports *A* and *D*, since, in general, the maximum bending moment produced by loads p, p when at the end of the cantilever, and that produced when the load is midway between *A* and *D* are about equal. But, more accurately, this ratio should be proportioned so as to obtain equal maximum fiber stresses in both cantilever and span, and thus a jib having a constant cross-section, such as a rolled beam or channel, can be economically employed. When loads p, p are acting between *D* and *E*, the maximum reaction *R* at *D*, when the trolley is at the extreme end of the cantilever, is the sum of the products of each of the wheel loads multiplied by the ratio of the long levers *AE* and AE_1 to the short lever *AD*. Expressing *AE*, AE_1, and *AD* in terms of the dimension letters, we have (see Fig. 1) b, $(b - d)$, and l, respectively. Then taking moments about *A*, the fulcrum of the lever, we have

$$R = p \times \frac{b}{l} + p \times \frac{(b-d)}{l} \qquad (1)$$

This reaction R produces a direct tensile stress between the points *A* and *D* of the jib, and a compressive stress in strut *CD*.

Let side *AC* of the triangle *ADC* in Fig. 1 represent the magnitude of this reaction R; then side *AD* represents the value of the tensile stress, or

$$\text{Stress in } AD = \frac{\text{side } AD}{\text{side } AC} \times R,$$

and, employing dimension letters l and g, we obtain

$$\text{Stress in } AD = \frac{l}{g} \times R.$$

Substituting the value of R of formula (1) for R, we have

$$\text{Stress in } AD = \frac{pb + p\,(b-d)}{l} \times \frac{l}{g} = \frac{pb + p\,(b-d)}{g} \qquad (2)$$

Before the section of the jib can be determined, it is required to find the maximum flexural stresses due to the live and dead load bending moments, and combine them with the axial or

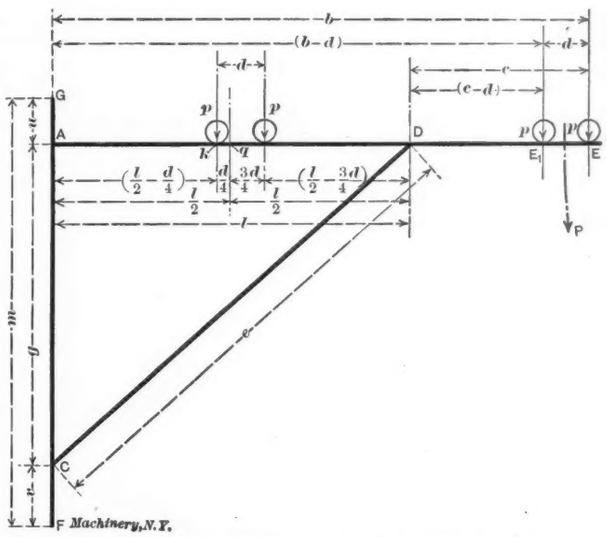

Fig. 1. Diagram of Type of Jib Crane selected for Analysis of Stresses.

direct tensile stresses acting on span *AD*, when the absolute maximum bending moment occurs, that is when the wheel loads p, p are so placed that the center of the span is midway between the center of gravity of these loads and one of the trolley wheels. They must also be combined with the stresses produced by the eccentric pull of the ropes holding the load.

The direct tensile stress in the jib to be so combined is then not the maximum one just found by formula (2), but that due to the reaction R_1 when the trolley is at the position in the span producing the greatest bending moment, and the value of that reaction R_1 at *D* is found by taking the moments about support *A*, or,

$$R_1 = \frac{p\left(l + \frac{d}{2}\right)}{l}$$

Value of R_2 at *A* is found by taking moments about support *D*,

$$R_2 = \frac{p\left(l - \frac{d}{2}\right)}{l}$$

To obtain the maximum live load bending moment we take

* For previous articles on this and kindred subjects, see "History of Crane Design," June, 1908; "Power Required for Cranes and Hoists," November, 1907, and other articles there referred to.

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moments about point k under one of the wheels (as shown in Fig. 1); then we have

$$\text{Maximum bending moment} = R_2 \times \left(\frac{l}{2} - \frac{d}{4}\right)$$

But as $R_2 = \dfrac{p\left(l - \frac{d}{2}\right)}{l}$, if we substitute this value of R_2 in the last equation, we find the greatest live load bending moment from

$$\text{Live load bending moment} = \frac{p}{2l}\left(l - \frac{d}{2}\right)^2 \qquad (3)$$

$$\text{Dead load bending moment} = \frac{wl}{8} \qquad (4)$$

$$\text{Approximate total bending moment} = \frac{p}{2l}\left(l - \frac{d}{2}\right)^2 + \frac{wl}{8} \qquad (5)$$

where d = wheel base,
w = weight of jib between supports A and D, which weight must be assumed,
$l = AD$, or span.

In regard to formula (5) it may be said that the customary approximate method of adding the maximum live load bending moment to the maximum dead load bending moment is incorrect, except in cases where the maximum live load bending moment occurs at the center of the span. The correct method for this case is to add to the maximum live load bending moment its increment of the dead load moment at that point, and not the maximum value which takes place at the center of the span. The usual method is sufficiently correct for practical purposes, however, as it is on the safe side.

The unit-stress f, due to bending, in pounds per square inch is found from

$$f = \frac{\frac{p}{2l}\left(l - \frac{d}{2}\right)^2 + \frac{wl}{8}}{Z} \qquad (6)$$

The unit-stress due to jib reaction R_1 is found from

$$f_1 = \frac{R_1 \times \frac{l}{g}}{a} = \frac{p\left(l + \frac{d}{2}\right)}{ag} \qquad (7)$$

Unit-stress f_2, due to tension of rope, is found from

$$f_2 = \frac{T}{a} + \frac{Tz}{Z} \qquad (8)$$

where T = tension in rope in pounds,
R_1 = value of reaction at D when greatest live load bending moment occurs,
z = eccentricity or distance between center line of rope and center line of member, in inches,
Z = section modulus of section,
a = area of section of member in square inches,
w = weight of jib between supports A and D, and
d, g, l, and p designate quantities as indicated in Fig. 1.

The maximum compressive stress in top flange of jib section $= f - f_1 + f_2$, or

$$\frac{\frac{p}{2l}\left(l - \frac{d}{2}\right)^2 + \frac{wl}{8}}{Z} - \frac{p\left(l + \frac{d}{2}\right)}{ag} + \frac{T}{a} + \frac{Tz}{Z}$$

or combining

$$f - f_1 + f_2 = \frac{\left[\frac{p}{2l}\left(l - \frac{d}{2}\right)^2 + \frac{wl}{8}\right] + Tz}{Z} + \frac{T - p\frac{\left(l + \frac{d}{2}\right)}{g}}{a} \qquad (9)$$

The maximum tensile stress in the bottom flange of jib when such flange is opposite to the line of action of the rope (see Fig. 3) $= f + f_1 - f_2$ (f_2 in this case being modified to give tensile stress in bottom flange, due to eccentricity of rope loading), or

$$\frac{\frac{p}{2l}\left(l - \frac{d}{2}\right)^2 + \frac{wl}{8}}{Z} + \frac{p\left(l + \frac{d}{2}\right)}{ag} - \frac{T}{a} + \frac{Tz}{Z}$$

or combining,

$$f + f_1 - f_2 = \frac{\left[\frac{p}{2l}\left(l - \frac{d}{2}\right)^2 + \frac{wl}{8}\right] + Tz}{Z} + \frac{\frac{p\left(l + \frac{d}{2}\right)}{g} - T}{a} \qquad (10)$$

These results should not exceed the specified fiber stress for the structure. Before selecting a structural shape to resist these maximum stresses just found, the stresses on the cantilever end should be considered as follows:

f = flexural stress due to bending.
f_1 = tensile stress due to jib reaction,
f_2 = compressive stress due to tension or pull of ropes.

Live and dead load maximum bending moment

$$= (p \times c) + [p \times (c - d)] + \left(w \times \frac{c}{2}\right) \qquad (11)$$

and f, or stress due to bending on cantilever

$$\text{Unit stress } f = \frac{pc + p(c - d) + \frac{wc}{2}}{Z} \qquad (12)$$

This maximum flexural stress takes place at D, and immediately to the left of D, there exists at the same time the direct tensile stress due to the maximum reaction R, when the trolley is at the extreme end of the cantilever producing this bending stress, found in formula (1), which also must be combined with the stress due to the pull of the rope. Therefore the unit-stress at point $D = f + f_1 - f_2$.

$$\text{Unit-stress } f_1 = \frac{Rl}{ag} = \frac{pb + p(b - d)}{ag} \qquad (13)$$

Stress due to pull of ropes $= f_2$.

$$\text{Unit-stress } f_2 = \frac{T}{a} + \frac{Tz}{Z} \qquad (8)$$

Therefore the maximum fiber stress $=$

$$f + f_1 - f_2 = \frac{pc + p(c - d) + \frac{wc}{2}}{Z} + \frac{pb + p(b - d)}{ag} - \left(\frac{T}{a} + \frac{Tz}{Z}\right)$$

or combining,

$$f + f_1 - f_2 = \frac{pc + p(c - d) + \frac{wc}{2} - Tz}{Z} + \frac{\frac{pb + p(b - d)}{g} - T}{a} \qquad (14)$$

where p = wheel load as before,
w = weight of section of jib from D to its extremity (see Fig. 1).

The compressive stress in strut CD is $R \times \dfrac{\text{side } CD}{\text{side } AC}$, of the triangle ADC, or $R \times \dfrac{e}{g}$.

And since R is maximum when the trolley is at the extreme end of the cantilever, or

$$R = \frac{pb + p(b-d)}{l} \quad (1)$$

then the maximum compressive stress in strut =

$$\frac{pb + p(b-d)}{l} \times \frac{e}{g} \quad (15)$$

$$\text{Unit-stress in strut} = \frac{[pb + p(b-d)]\,e}{agl}, \text{ (see Fig. 1).} \quad (16)$$

where a equals area of cross-section of strut.

The allowable unit-stress per square inch of section of this member is found by the usual Gordon formulas

$$\text{for structural steel, } f = 17{,}100 - 57\frac{l}{r} \quad (17)$$

$$\text{for yellow pine, } f = 1{,}200 - 18\frac{l}{t} \quad (18)$$

However, a satisfactory reducing formula of the Rankine type, extensively used by bridge companies, and specified by some railroad companies, is recommended. It is as follows:

$$\text{for structural steel, } f = \frac{15{,}000}{1 + \frac{l^2}{13{,}500\,r^2}} \quad (19)$$

$$\text{for yellow pine, } f = \frac{1{,}200}{1 + \frac{l^2}{250\,t^2}} \quad (20)$$

where l = length of strut in inches,
t = thickness of timber in inches,
r = least radius of gyration.

The stress in the strut due to its own weight is neglected as being very small in most practical cases.

Ordinarily the ratio $\frac{l}{r}$ should not exceed 130; however, this ratio is frequently increased if the fiber-stress is well under the one specified, and as long as its departure from straightness will not subject the strut to an appreciable bending moment.

The stresses that may exist in the mast are as follows: (See Fig. 1.)

(1) Axial compression due to reaction R_3 and weight of structure.

(2) Eccentric stress due to R_3 when trolley is at extreme position on jib next to mast for cranes where jib connects to the face of the mast, and not at the center line of gravity of its section.

(3) Eccentric flexural stress due to tension in ropes.

(4) Flexural stress due to direct tension in jib AE, and to the horizontal component of direct compression in the strut DC.

(5) Eccentric flexural stress due to weight of drum and other hoisting machinery. This last stress is usually disregarded, however, except where the jib and hoisting machinery are of abnormally large proportions.

$$\text{Unit-stress } f'_1 = \frac{R_3}{a},$$

but

$$R_3 = \frac{pl + p(l-d)}{l}$$

therefore

$$f'_1 = \frac{\frac{pl + p(l-d)}{l}}{a} = \frac{pl + p(l-d)}{al} \quad (21)$$

$$\text{Unit-stress } f'_2 = \frac{R_3}{a} + \frac{R_3 z_1}{Z} \text{ (see Fig. 3),}$$

but

$$R_3 = \frac{pl + p(l-d)}{l}$$

therefore

$$f'_2 = \frac{pl + p(l-d)}{l}\left(\frac{1}{a} + \frac{z_1}{Z}\right) \quad (22)$$

$$\text{Unit-stress } f'_3 = \frac{T}{a} + \frac{Tz_2}{Z}\cos\theta \quad (23)$$

$$\text{Tension in jib} = H = \frac{pb + p(b-d)}{g} \text{ (see Fig. 2)} \quad (2)$$

The horizontal component of stress in strut is equal to the tension H. The mast is then considered as a beam supported by reactions H and r. (See Fig. 2.)

$$r = \frac{p \times b + p(b-d) + w_1 \times j}{m} \quad (24)$$

where w_1 = weight of structural frame,
j = distance from center of mast to center of gravity of frame,
m = distance between centers of bearings.

The quantity $w_1 \times j$ may be omitted when the frame is not very large. The maximum bending moment in the mast is then $r \times u$ or $r \times v$, whichever is greatest. Distances GA and CF, Fig. 1, should be as small as consistent with the design to obtain economy.

$$\text{Unit-stress } f'_4 \text{ at cantilever } GA = \frac{ru}{Z}$$

$$\text{Unit-stress } f'_5 \text{ at cantilever } CF = \frac{rv}{Z} \quad (25)$$

The axial compressive stress in the mast due to the whole weight of the structure, should be added to the flexural compressive stress f_4' due to bending when the trolley is at the extreme end of the jib, since that part of the mast immediately beneath C is subjected to both at the same time under these conditions.

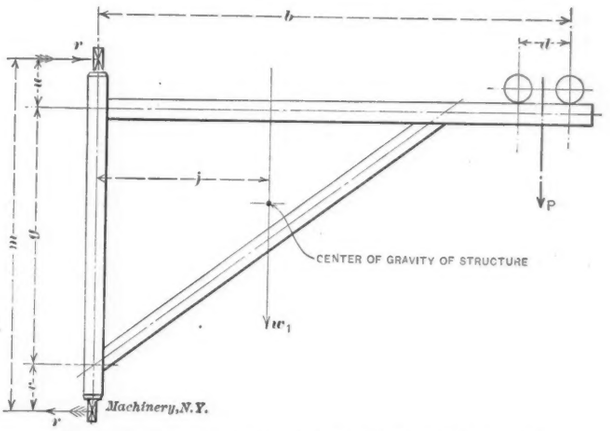


Fig. 2. Outline of Crane for which the Design is Calculated.

The stress f_4' is not added to the stress f_2' as found by formula (22), because they do not take place at the same time, the maximum bending taking place when the trolley is at the end of the jib, and the maximum eccentric compressive stress when the trolley is close to the mast.

It is sometimes required, when long jib members are necessary, to brace the two shapes composing the jib at some intermediate point in order to reduce the ratio $\frac{l}{r}$, and, at the same time, lessen the tendency of the jib members to spread. This is done by securing structural shapes bent clear over the jib trolley. (See Fig. 4.) The ratio $\frac{l}{r}$ should not exceed that above specified.

The pintles at G and F should be made large enough to resist the bending moment on them, and also designed for a safe bearing pressure per square inch of their projected area. This pressure is the quantity r in formula (24).

The jib end connection is subjected to flexural stresses due to the tension of the rope or ropes, which should be taken into consideration. The connection is treated as a beam, and the pull of the rope or ropes as concentrated loads in the middle or at equal distances from the middle, according to the kind of connection employed, the beam in question being supported at both ends.

Example.

Required to design a jib crane of the underbraced type to lift a load of 10,000 pounds at a radius of 21 feet 6 inches; distance between underside of roof truss or top support and floor 13 feet 6 inches; jib to be constructed of two structural steel frames composed of standard size channels and connected together (see Fig. 4); trolley mounted on four wheels running on top flanges of jib member. Maximum fiber-stress 13,000 pounds per square inch, which is allowable for hand-power machines. For a load of 10,000 pounds we will use four parts of 7/16-inch—6 strands of 19 wires—plow steel hoisting rope, having a breaking strength of 17,700 pounds, and will give a factor of safety of $\frac{4 \times 17{,}700}{10{,}000} = 7.08$, **which must also take care of the bending stresses in the ropes. This size of rope will require sheaves of 14 inches in diameter, and will allow a wheel base of 36 inches. Two ends of these two lengths of rope will wind on the drum, and the other two ends will be supported at the outer end of the jib by an equalizing beam.**

Load to be lifted	10,000 pounds
Approximate weight of trolley, ropes and block	500 pounds
Total	10,500 pounds

which will make the wheel loads $\frac{10{,}500}{4} = 2{,}625$ pounds each.

Distance between mast and joint D, Fig. 3, = 208 inches.

Distance between jib and joint C = 120 inches.

Distance between mast and extreme position of outermost wheels of trolley = effective radius + half the wheel base = 21 feet 6 inches + 1 foot 6 inches = 23 feet = 276 inches.

Let us first assume the trolley at that position in the span AD producing the greatest bending moment (see Fig. 1).

Maximum live load bending moment

$$= \frac{2625}{2 \times 208}\left(208 - \frac{36}{2}\right)^2 = 227{,}793 \text{ inch-pounds.} \quad (3)$$

By looking at the table of properties of steel channels in any steel company's handbook, we find that a 12-inch channel weighing 20.5 pounds per foot, with an area of 6.03 square inches, has a section modulus about the axis perpendicular to the web of 21.4, and this value divided into the live load bending moment will give a stress of 10,644 pounds per square inch, which leaves us a margin for the other stresses yet to be considered. Therefore, we will temporarily select the above shape for the purpose of finding the bending-moment due to the uniform weight of the member itself.

Weight of channel between A and D $= \frac{208}{12} \times 20.5 = 355$ pounds.

Dead load bending moment $= \frac{355 \times 208}{8} = 9{,}230$ inch pounds. (4)

Approximate total bending moment

$$= 227{,}793 + 9{,}230 = 237{,}023 \text{ inch-pounds.} \quad (5)$$

Unit stress due to bending

$$= \frac{\frac{p}{2l}\left(l - \frac{d}{2}\right)^2 + \frac{wl}{8}}{Z} = \frac{237{,}023}{21.4} = 11{,}076 \text{ pounds per square inch.} \quad (6)$$

Unit-stress due to reaction R_1

$$= \frac{2625 \times \left(208 + \frac{36}{2}\right)}{120 \times 6.03} = 817 \text{ pounds per square inch.} \quad (7)$$

Tension in ropes $= \frac{10{,}000}{4} = 2{,}500$ pounds.

Unit-stress due to tension in rope

$$= \frac{2{,}500}{6.03} + \frac{2{,}500 \times 8}{21.4} = 1{,}348 \text{ pounds per square inch.} \quad (8)$$

Total stress on top flange $= f - f_1 + f_2 = 11{,}076 - 817 + 1{,}348 = 11{,}607$ pounds per square inch (9), which stress is under the one specified; the shape tentatively selected may therefore be used for this member of the crane.

Weight of cantilever end of jib $= \frac{93}{12} \times 20.5 = 159$ pounds.

Unit stress due to bending

$$= \frac{2{,}625 \times 68 + 2{,}625 \times 32 + 159 \times \frac{93}{2}}{21.4} = 12{,}613 \text{ pounds per sq. inch.} \quad (12)$$

Unit-stress due to reaction R

$$= \frac{2{,}625 \times 276 + 2{,}625 \times (276 - 36)}{120 \times 6.03} = 1{,}872 \text{ pounds per sq. inch.} \quad (13)$$

Unit-stress due to pull in rope

$$= \frac{2{,}500}{6.03} + \frac{2{,}500 \times 8}{21.4} = 1{,}348 \text{ pounds per square inch.} \quad (8)$$

Total unit-stress on top flange of cantilever = 12,613 + 1,872 — 1,348 = 13,137 pounds per square inch, (14) which is 137 pounds per square inch more than the specified stress. In practice, this will not be considered of sufficient importance to change the design.

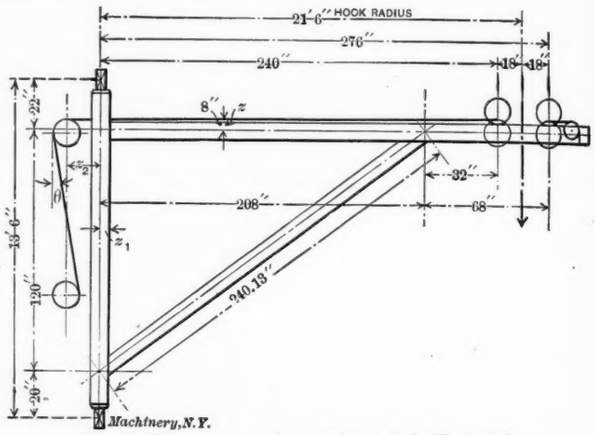


Fig. 3. General Dimensions of Crane to be Designed.

Total length of jib member = 25 feet 1 inch, or 301 inches.

Least radius of gyration of 12 × 20.5 pounds channel = 0.81.

The ratio $\frac{\text{length}}{\text{least radius of gyration}} = \frac{301}{0.81} = 371$, consequently the channels of the two frames should be braced at least at a point midway between the end connection and the mast. (See Fig. 4.)

Length of strut $DC = \sqrt{120^2 + 208^2} = 240.13$ inches. Selecting a 15 × 33-pound channel having a cross-sectional area of 9.9 square inches, and least radius of gyration of 0.91, for strut, we have the compressive unit-stress

$$= \frac{[2{,}625 \times 276 + 2{,}625\ (276 - 36)] \times 240.13}{208 \times 120 \times 9.9} = 1{,}316 \text{ pounds per square inch.} \quad (16)$$

$$\text{Allowable stress} = \frac{15{,}000}{1 + \frac{240.13^2}{13{,}500 \times 0.91^2}} = 2{,}440 \text{ pounds per sq. inch.} \quad (19)$$

The ratio of the length of the strut to its least radius of gyration is $\frac{240.13}{0.91} = 264$, which is excessive; the maximum unit-stress, however, is very low, only 1,316 pounds per square inch, or hardly more than half of that allowed by the formula (19). As there is not a channel rolled by any mill with a greater "least radius of gyration" than the one we have employed, we may stiffen the strut laterally by riveting an angle to its web in the inside or back of channel. Unless the ratio 130 must be adhered to, the channel should be left as it is as long as the member shows no great deflection under load.

Let us now investigate the stresses existing in the mast, which we assume is composed of two 12 × 20.5-pound channels. The distance from center of mast to nearest wheel when the trolley is at the extreme position next to mast = 11 inches.

$$\text{Then } R_3 = \frac{2{,}625\ (208 - 11) + 2{,}625\ (208 - 11 - 36)}{208} = 4{,}518$$

pounds.

As the two vertical shapes composing the mast are latticed together, we will take the two equal reactions R_3 (one which acts on one channel and the other on the opposite one) to be resisted by the two shapes combined, therefore the least radius of gyration of the mast as built is then that perpendicular to the web of the channels, whose value is 4.61.

Then the allowable compressive stress

$$= \frac{15{,}000}{1 + \frac{162^2}{13{,}500 \times 4.61^2}} = 13{,}761 \text{ pounds per sq. inch.} \quad (19)$$

Unit-stress f'_1

$$= \frac{2{,}625\ (208 - 11) + 2{,}625\ (208 - 11 - 36)}{6.03 \times 208} = 749 \text{ pounds per square inch.} \quad (21)$$

Maximum bending moment on channel = 2,500 × (9 — 4) = 12,500 inch-pounds.

$$\text{Unit-stress} = \frac{12{,}500}{1.75} = 7{,}143 \text{ pounds per square inch.}$$

Horizontal reaction on pintles

$$r = \frac{2{,}625 \times 276 + 2{,}625\ (276 - 36)}{162} = 8{,}361 \text{ pounds.} \quad (24)$$

Assuming the pintles to be 4 inches long, and taking moments about a lever arm from the center of the bearing to the support (= 2 inches), we have, bending moment = 8,361 × 2 = 16,722 inch-pounds. Unit-stress on pintles should not exceed 9,000 pounds per square inch for machine steel.

Section modulus of a circular section $= \frac{\pi d^3}{32} = 0.098 d^3$, where d = diameter of section.

$$\text{Diameter of pintle} = d = \sqrt[3]{\frac{16722}{0.098 \times 9000}} = 2.66 \text{ inches.}$$

The bearing pressure on pintles should not exceed 1,000 pounds per square inch of projected area. Therefore $\frac{8{,}361}{1{,}000}$ = 8.36 square inches are required. We will make the pintles 2¾ inches in diameter by 4 inches in length, which will give a bearing pressure of $\frac{8{,}361}{2.75 \times 4} = 760$ pounds per square inch.

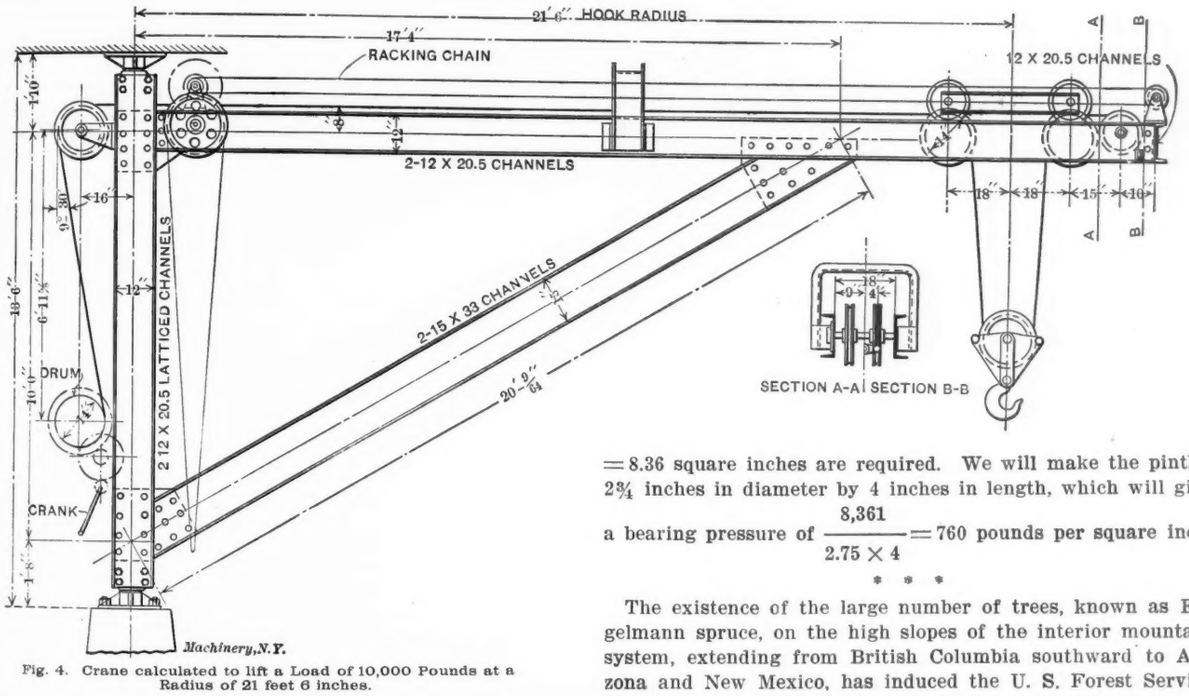


Fig. 4. Crane calculated to lift a Load of 10,000 Pounds at a Radius of 21 feet 6 inches.

Stresses f'_2 do not take place in this gusset-connected frame.

Unit-stress f'_3 due to tension of rope

$$= \frac{2{,}500}{6.03} + \frac{2{,}500 \times 16}{21.4} \times \cos 9 \text{ deg. } 30 \text{ min.} \quad (23)$$

= 2,257 pounds per square inch. (See Fig. 4.)

Horizontal reaction at top and bottom of mast when load is at extreme outside end of jib =

$$r = \frac{2{,}625 \times 276 + 2{,}625\ (276 - 36)}{162} = 8{,}361 \text{ pounds.} \quad (24)$$

Unit-stress f'_4 due to bending moment at top of mast =

$$\frac{8{,}361 \times 22}{21.4} = 8{,}548 \text{ pounds per square inch.} \quad (25)$$

Maximum unit-stress immediately beneath point A of mast = $f'_4 + f'_3 = 8{,}548 + 2{,}257 = 10{,}805$ pounds per square inch.

For the end connection of the jib at E we select a 12-inch × 20.5 pounds channel for the sake of symmetry, and proceed to investigate the bending stress to which it is subjected due to the pull of the ropes. The distance between the jib members is 18 inches. The pull on the ropes is 2,500 pounds. The section modulus of the channel in consideration about an axis parallel to the web is 1.75. Two ropes, both four inches from the center of connecting channel are used (see Fig. 4).

* * *

The existence of the large number of trees, known as Engelmann spruce, on the high slopes of the interior mountain system, extending from British Columbia southward to Arizona and New Mexico, has induced the U. S. Forest Service to undertake experiments to determine whether this tree, which is comparatively small and which is not considered a very valuable timber tree, can be used for making paper pulp. Samples have been received from the national forests of Wyoming, Colorado and Utah, and these have been treated by the sulphite process, and pulp obtained from which is secured paper fully as good as that made from Eastern spruce. The results of preliminary trials on seasoned wood shows that it gives a fiber fully as valuable as that from its Eastern relative. The fiber of Engelmann spruce seems to be slightly shorter than that of the Eastern spruce, but it is of sufficient length to be used for the latter in nearly all the manufactured products, and there is apparently no reason why it should not be so used provided that other conditions of manufacture and transportation are favorable.

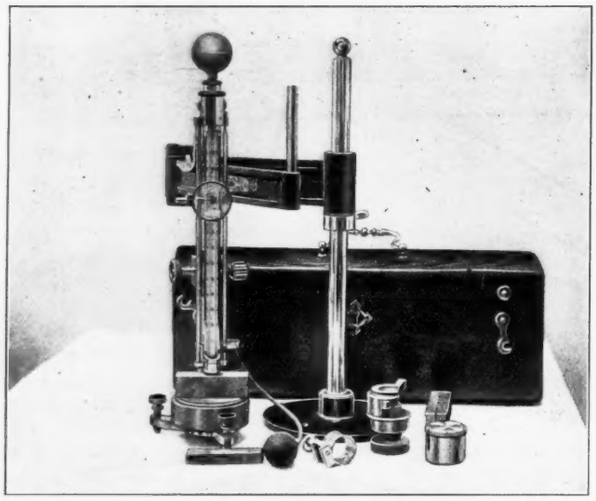
* * *

It is stated in the *English Mechanic and World of Science* that an English company has succeeded in obtaining photographic films where the natural colors of the objects photographed are reproduced. The photographs are obtained by a direct method, and are made for use in a moving picture apparatus. The company has given an exhibition of the results obtained to members of the press, and it appears that this invention marks a decided advance in color photography.

A NEW MECHANICAL TEST FOR HARDNESS.*

J. F. SPRINGER.†

Even when men first began to harden steel, they probably sought some method of ascertaining in particular cases whether their object had been accomplished. Perhaps the testing tool was nothing more than a fragment of flint or another piece of steel known to be hard. Certain jewels—as the diamond—are well suited to a process which depends upon scratching. In fact, this process is in common use everywhere even at the present day. The test by filing is not to be despised as it is easily applied, and if the file is a good one, the results are sufficiently accurate and reliable for a considerable class of work. But the file is an instrument inadequate to the requirements of modern metallurgists and manufacturers. This is true for two reasons: First, the alloy steels seem to possess the property of being able to resist a file, apart from hardness. Thus, a piece of manganese self-hardening tool steel may be, in reality, softer than a specimen of a pure carbon steel, and yet resist the attacks of the file equally well. In explanation of this phenomenon, it has been suggested that the hard manganese resists the file while the iron substratum remains soft. The combination as a whole would not be so hard, although able to withstand the file. This, however, seems really to involve the proposition that such steel is not a perfect chemical combination,



The Scleroscope—An Instrument for Testing the Hardness of Metals.

but that particles of manganese are held imbedded in iron or an iron alloy. Perhaps this may be so, but if it is true, then the action of such steel on the file is very similar to that of an emery wheel. The emery itself is very hard, but is held in a matrix that is soft. However, whether we accept this explanation or not, it is doubtful whether we have good reason to contend that a specimen of alloy steel is as hard as a piece of pure carbon steel, merely because it resists the file equally well.

The second objection to the file is that it affords no reliable means of making accurate comparisons between different degrees of hardness. It is sometimes of importance in cases where one element of a machine slides against another to ascertain which of the two is the harder. The difference may be very slight, yet it will readily be granted that this difference might become of importance if lubrication failed. For, the harder piece would then cut or wear the softer. If such a contingency is possible, then it is important that the more expensive part shall be the harder. A little reflection will convince one that this principle of associating a harder valuable part with a softer less valuable part, has application everywhere in machine construction; but in order to apply this principle widely, it is necessary to be able to determine differences in hardness where these differences are quite small in amount.

A modern instrumental means of testing for small differences in hardness is that known as the Brinell device. In accordance with this method, a steel ball is pressed against the specimen to be tested. The permanent indentation formed is then measured—say, for depth. Assuming that, with the compression the same and with a ball of the same size and hardness, the variations in depth of indentation furnish a means of quantitatively determining variations in the degree of hardness; it only remains to measure these depths with sufficient accuracy, and we shall obtain, by referring to a previously calculated table, a series of numerical values expressing the variations in hardness. Of course, the deeper the indentation, the softer the substance; so that if it is desired that the numbers increase with the increase in hardness, we have only to take the reciprocals. This mechanical test for hardness has found pretty extended introduction. But it may well be questioned whether hardness is really tested by the slow formation of an indentation. There can be no doubt that resistance to slow penetration is tested by this procedure, but is resistance to slow deformation what we mean by hardness? I scarcely think so.

A piece of sealing-wax resists deformation but feebly if the deforming procedure is applied gradually. We should hardly say that the hardness of this substance is of so low a degree as this slight resistance to slow displacement of its particles would indicate. Then again, it is quite conceivable that toughness might so contribute its assistance in withstanding a slow deformative process that the result could not be looked on as an accurate indication of hardness alone. Now what we call toughness appears to be slow in its operation. That is, at the beginning of a deformative effort there is a yielding of the particles; this is followed by resistance to further displacement. But time seems to be required for the development of this resistance. What we call hardness appears to be, on the contrary, a resistance that is instantly available. That is to say, in hardness there is an instantaneous resistance to displacement of particles. This conception of the difference between hardness and toughness as the difference between an instantaneous and a slower recovery of particles, seems to strike close to the truth. Adopting this distinction as a true criterion, we should derive a test for hardness by testing for the instantaneous recuperative power of metals.

In the process employed by Mr. Shore (Shore Instrument & Mfg. Co., 226 W. 24th St., New York City), carried out by means of the hardness-testing instrument (the scleroscope—see Fig. 1) which he has developed, the energy of resistance at the moment when the elastic limit is exceeded seems to be the thing measured. And this would appear to be just about what we mean by hardness. A tiny hammer, pointed at the lower end, falls from a fixed height upon the specimen, striking a blow exceeding the elastic limit. The rebound is then measured.

In the first experiments, a steel ball was used as the hammer, but the results were only partially satisfactory. In fact, the inventor was well-nigh on the point of giving up when he met a French expert in metals by the name of Dr. Herould. Following out certain of his suggestions, Mr. Shore has succeeded in producing an instrument which apparently gives great promise of solving the problem of the testing of hardness. The difficulty with the ball-shaped hammer was that it was incapable of striking a sufficiently hard blow to get adequate results, especially with hardened tool-steel, so the area of contact was reduced, although the weight was kept large in comparison. In fact, the blow struck by the sharper of the two varieties of hammer used in the scleroscope, is estimated at 75,000 pounds per square inch. The point which strikes is, however, so small on the tip that with a fall of ten inches the weight of the whole hammer is required to be but a small fraction of an ounce.

But the determination of these points, while important, was not by any means a complete solution. A great difficulty arose in connection with the material for the hammer; it was necessary to have extraordinary hardness combined with a non-crystalline structure. The diamond was found unequal to the requirements of the case, and after much investigation in which the scleroscope—although itself still imperfect—assisted, a method of treating tool steel was developed, which

* For additional information on this subject, see the article on "The Brinell Method of Testing the Hardness of Metals" published in the September, 1908, issue of MACHINERY.

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produces, under favorable conditions, a very hard steel capable of the exacting duty required. The absolute weight of the entire hammer is little, but relatively to the striking area it is very great. This hammer, having a cylindrical body, is guided in its fall by a glass tube. Great difficulty has been experienced in getting tubes with a sufficiently perfect bore. There seems to be no commercial method of manufacturing such tubes, so the method of test-and-reject is employed, resulting in a very great waste.

The tube is secured to a frame in a vertical position with the lower end open. Upon exhausting the air by means of a rubber bulb connection, the hammer is drawn to the top where it is held by a suitable catch. When it is desired to release the hammer, a hook, seen in Fig. 1 at the top and to the left, is drawn downwards by the left hand while the right compresses a second rubber bulb, seen on the table. Upon releasing the bulb, the hammer drops and its point strikes sharply the piece of metal to be tested. The rebound of the hammer is measured against a scale graduated from 0 to 140, secured in position back of the glass tube. To aid in reading the rebound, a magnifying glass is supplied. After some practice, its assistance may be dispensed with, if desired.

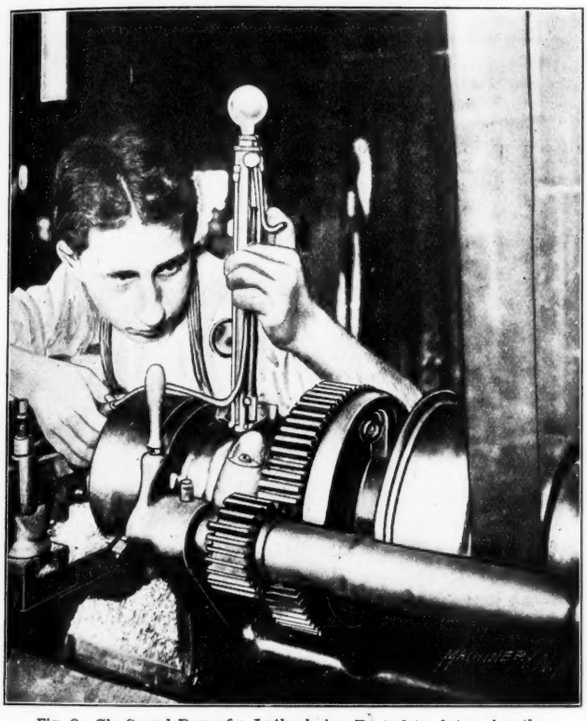

Fig. 2. Shaft and Box of a Lathe being Tested to determine the Relative Hardness.

However, to use it, it is secured in such position as to cover the possible region of the expected reading. The rod to the left of the tube is the support to which the magnifying attachment is secured and along which it is adjustable. The rod to the right of the tube is a plumb-rod; it swings freely from a point of attachment above, and enables the operator to keep the tube vertical.

The instrument proper—that is, apart from the supporting stand—may be used to test parts of machinery in position. In this way a shaft and box may be tested to determine the relative hardness. See Fig. 2. In using the instrument with the stand, the specimen is placed on the table or secured in a holder. It is necessary that the actual point tested should be clean and horizontal, and that the piece should be firmly held. If the specimen is quite irregular, it may be held in a support of asphaltum and tar. This combination, while yielding to slow pressures, is quite unyielding when the blow is instantaneous—as with the scleroscope hammer. Of course, the upper part of the specimen at the point to be tested must be horizontal. If necessary to test more than once, the piece should be slightly moved so as to expose a fresh point to the hammer. The indentation made is, however, very minute, so that several are usually unobjectionable.

The scale, as already mentioned, runs from 0 to 140. The hardness of the finest steels ranges from 100 to 110. Porcelain and glass have higher grades, while unhardened steels, brass, zinc, and lead show lower and lower degrees. Unhammered or unrolled lead produces a rebound of but two graduations. The question may arise with some whether the graduations should all be of equal size—whether, in fact, they should not progressively increase as one goes from one end of the scale to another. It seems that there should be no difference. What it is desired to measure is the energy of the rebound. Now the energy of falling (or rebounding) bodies varies with the first power of the space traversed, so that with equal increases of energy we shall have equal increases of the space rebounded. The scale may be regarded, then, as affording readings which are strictly proportional to the energy of resistance of the metal being tested, when the elastic limit is exceeded. If we regard this energy of resistance as indicative of what we mean by hardness, then the scleroscope seems to fulfill the requirements of a scientific measurer of this important property of metals.

One of the great results of the introduction of scientific methods of precise quantitative measurement of hardness, promises to be in the determination of the relation of the cutting tool to the work to be machined. We are all aware that the tool must be harder; but how much harder? And how express this relation in intelligible language? The scleroscope, it is hoped, will afford a pretty definite answer to this problem. The law has been laid down that the comparative hardness between tool and work as determined by scleroscope readings, should be in the ratio of 3 to 1 or 4 to 1, in order to secure the best commercial results. In illustration of this point, we may take the case of work to be machined consisting of a 1 per cent carbon tool steel. Unannealed, such steel is found upon testing to disclose a hardness varying from 40 to 45 points. According to the above law, the cutting tool should be at least about 120 to 135 hard; but the same steel properly annealed, is only about 31 hard. Consequently, it is not at all difficult to find a suitable material for the cutting tools. Thus, a fine quality of pure carbon tool steel, well hardened, has a hardness of 95 to 110, and is consequently suitable to cut material of a hardness of 31. Now if this principle as to relative hardness necessary, can be thoroughly established for all kinds of metals, an element of scientific certainty will be introduced into machine practice. This will make for economy of time and tool.

Again, it is, of course, to be expected that if two metal parts wear or rub against each other, the harder of the two will cut the softer, whether the difference is small or great, so that it is often important to know whether the more expensive part is really the harder. The scleroscope would seem to afford a means of determining with precision slight differences in hardness, thus enabling the manufacturer to assemble contacting moving parts on the principle of a harder expensive piece in association with a softer cheaper one. Thus in an electrical repair shop, instances may readily be found of the steel shaft cut by the brass box, the box cut by the shaft, and a pretty even wear of both. From an economical point of view, it is much better to have the brasses worn than the shaft, and with such an instrument as the scleroscope it would be possible to predetermine this economically better result. It would seem an easy matter for an automobile manufacturer, say, so to specify the hardness of the gear wheels used, that the gear manufacturer could supply him with a uniform product.

A further illustration, which suggests itself, is the possibility of assembling the outer and inner rings of ball bearings so as to equalize the wear of the two raceways. Other things being equal, the inner raceway wears more rapidly because the convex ball contacts with a rather sharply convex raceway (convex as seen transversely), while in the case of the outer raceway the convex ball contacts with a more gradual and concave curve. By adjusting this inequality through association of a hard inner ring with a softer outer ring, the wear may be equalized.

An important application of quantitative hardness tests, would appear to be in connection with high-speed steels. Now such steels disclose upon testing with this instrument, a

hardness varying from 80 to 105. This is at ordinary temperatures, however, and shows scarcely as high a degree as the best of the pure carbon steels. The effectiveness of high-speed steels depends largely upon the fact that at temperatures of 600 to 1,000 degrees, at which pure carbon steels would lose their temper, they retain a high degree of hardness, amounting, say, to 75 on the scleroscope scale. This is sufficient—following the principle of 3 to 1—to do heavy machining on annealed machinery steel measuring 25 on the same scale. But, if the heat developed by high speed and heavy cuts, succeeds in lowering the high-speed steel of the tool much lower than 75, then it is no longer an effective tool. It becomes of importance then to test high-speed steels for their effectiveness under temperature conditions obtaining in actual service. It is a small matter to know that a certain tool of high-speed steel is very hard when cold; what is its condition when hot? By heating the tool to the required temperature, and then testing with the scleroscope, its condition may be determined. It is thought that thus the real effectiveness of the high-speed steels may be determined in advance of their use or even of their purchase.

It is deserving of serious consideration that the scleroscope method is not limited to particular metals. It seems applicable to practically all the metals, not only for comparing different varieties of the same metal, but for comparing specimens of different metals. Thus, as already pointed out, brass may be compared with steel.

* * *

BAND AND BLOCK BRAKES.

A. L. CAMPBELL.*

Formulas for band and block brakes are not easily obtained, because many mechanical hand-books do not give any information on this subject. In order to supply a possible need in this direction, the formulas given in the current supplement have been compiled. These formulas are based on, and agree in form with, the formulas for these classes of brakes given in "Des Ingenieurs Taschenbuch," published by the Hütte Association, Berlin, Germany.

In any band brake, such as shown in Fig. 1 in the Supplement, where the brake wheel rotates in a clockwise direction, the tension in that part of the band marked x equals $P\frac{1}{e^{\mu\theta}-1}$; and in that part marked y, the tension equals $P\frac{e^{\mu\theta}}{e^{\mu\theta}-1}$. In these expressions,

P = tangential force in pounds at rim of brake wheel,
e = base of natural logarithms = 2.71828,
μ = coefficient of friction between the brake band and the brake wheel,
θ = angle of contact of the brake band with the brake wheel expressed in radians (one radian = $\frac{180 \text{ deg.}}{\pi}$ = 57.296 degrees).

For simplicity in the formulas presented, the tensions at x and y (Fig. 1, band brakes) are denoted T_1 and T_2, respectively, for clockwise rotation. When the direction of the rotation is reversed, the tension in x equals $T_2 = P\frac{e^{\mu\theta}}{e^{\mu\theta}-1}$ and the tension in y equals $T_1 = P\frac{1}{e^{\mu\theta}-1}$, which is the reverse of the tension in the clockwise direction.

The value of the expression $e^{\mu\theta}$ occurring in these formulas may be most easily solved by means of logarithms. The value of $e^{\mu\theta}$ is found by multiplying the logarithm of e by the product of the numerical values of μ and θ, and finding the number whose logarithm is equal to the result of this multiplication. The procedure may be best illustrated by an example.

In a band brake of the type in Fig. 1 in the Supplement, dimension $a = 24$ inches, and $b = 4$ inches; force $P = 100$ pounds; coefficient $\mu = 0.2$, and angle of contact = 240 degrees, or $\theta = \frac{240}{180} \times \pi = 4.18$. The rotation is clockwise. Find force F required.

$$F = \frac{Pb}{a}\left(\frac{e^{\mu\theta}}{e^{\mu\theta}-1}\right) = \frac{100 \times 4}{24}\left(\frac{2.71828^{0.2\times 4.18}}{2.71828^{0.2\times 4.18}-1}\right) =$$

$$\frac{400}{24} \times \frac{2.71828^{0.836}}{2.71828^{0.836}-1} = 16.66 \times \frac{2.31}{2.31-1} = 29.4.$$

The formulas given for the brakes in the Supplement are not empirical, but are theoretically correct. They can be mathematically verified. By means of calculus the values represented by T_1 and T_2 for the band brakes may be deduced, while the various expressions for F are obtained by equating the moments of the forces involved about any point of the brake, preferably about its fulcrum, or fixed point. For the block brakes the whole question is one of moments. For example, in Fig. 3, for clockwise rotation, by taking moments about the fulcrum we obtain $F(a+b) - Pc = \frac{Pb}{\mu}$,

From which

$$F = \frac{\frac{Pb}{\mu} + Pc}{a+b} = \frac{Pb}{a+b}\left(\frac{1}{\mu} + \frac{c}{b}\right)$$

The calculations for determining the value of $e^{\mu\theta}$ are rather cumbersome, and the accompanying table is appended in order to save the computation of this value for certain values of μ, and certain angles θ.

TABLE OF VALUES OF $e^{\mu\theta}$.

Proportion of Contact to Whole Circumference. $\frac{\theta}{2\pi}$	Steel Band on Cast Iron, $\mu = 0.18$	Leather Belt on Wood. Slightly Greasy. $\mu = 0.47$	Leather Belt on Cast Iron. Very Greasy. $\mu = 0.12$	Leather Belt on Cast Iron. Slightly Greasy. $\mu = 0.28$	Leather Belt on Cast Iron. Damp. $\mu = 0.38$
0.1	1.12	1.34	1.01	1.19	1.27
0.2	1.25	1.81	1.16	1.42	1.61
0.3	1.40	2.43	1.25	1.69	2.05
0.4	1.57	3.26	1.35	2.02	2.60
0.425	1.62	3.51	1.38	2.11	2.76
0.45	1.66	3.78	1.40	2.21	2.93
0.475	1.71	4.07	1.43	2.31	3.11
0.5	1.76	4.38	1.46	2.41	3.30
0.525	1.81	4.71	1.49	2.52	3.50
0.55	1.86	5.63	1.51	2.63	3.72
0.6	1.97	5.88	1.57	2.81	4.19
0.7	2.21	7.90	1.66	3.43	5.32
0.8	2.47	10.60	1.83	4.09	6.75
0.9	2.77	14.30	1.97	4.87	8.57
1.0	3.10	19.20	2.12	5.81	10.90
1.5	5.45	.....	....	....	....
2.0	9.60	.....	....	....	.....
2.5	16.90	.....	....	....	.....
3.0	29.80	.....	....	....	.....
3.5	52.40	.....	....	....	.....

* * *

An interesting little slide rule has been brought out by Kolesch & Co., New York. This slide rule is only about half as long as the ordinary slide rule, and its weight does not exceed 1½ ounce; but it can be used to the same advantage, with equal reliability and accuracy, as the larger rules. The subdivisions are the same as those of the larger instruments, and in order to make it possible for the eye to read off the results with the same convenience as on a larger rule, a magnifying glass is placed in the runner, so that the divisions appear to the eye as clearly as those of larger slide rules.

* * *

Somebody asked the successful business man how he managed to accomplish so much. He smiled as he told them that the secret lay in always doing the next thing next.—*The Silent Partner.*

* Address: Solvay Process Co., Engineering Dept., Detroit, Mich.

METHOD OF LAYING OUT AND CUTTING CAMS.*

HERBERT C. BARNES.†

Working by guess, or by the rule of thumb, is practiced quite as much, if not more, in the making of cams as in any other kind of machine work. Possibly this is so because a little leeway is generally given for the action of cams in the design of many machines, and the time-honored cut and try methods are relied on to bring the movements within necessary limits. It is certainly a fact that many a man who has laid out and cut cams does not know just what their performances will be until they are assembled in their machine and tested.

In this article we will consider the method of laying out a cam the requirements of which are as complicated in principle as any ordinarily used. We will then review a process

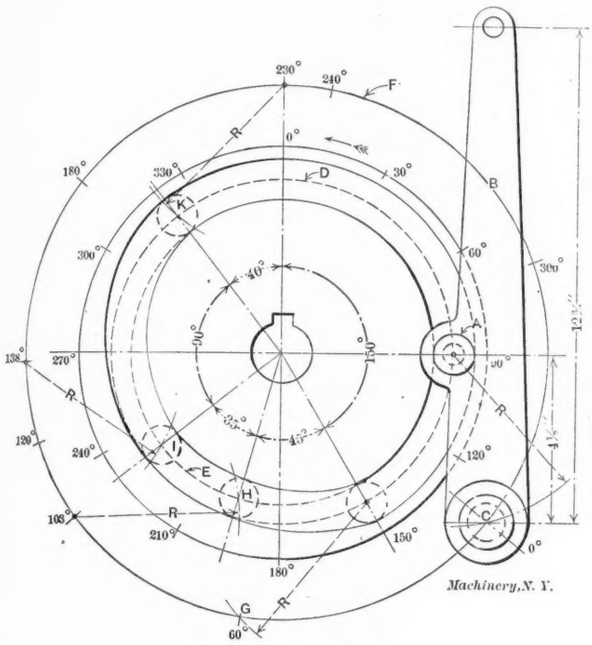

Fig. 1. Layout of Cam.

for making the master cam, which is generally used, and also another process not generally employed, but of much greater service.

The cam which we will lay out is seen in Fig. 1. It turns toward the left and moves a 1-inch roller *A* which controls the lever *B* swinging on the stud *C*. The cam is to be keyed to a shaft, together with several other cams, in all of which the keyway is at the beginning of the cycle. The requirements which follow are selected to illustrate as simply as may be the method employed. The head of the lever *B*, which is 12⅜ inches long, is to remain at rest until the cam has turned 150 degrees from the zero point or beginning of the cycle; it is then to advance 1½ inch in 43 degrees; then it will dwell for 35 degrees more, and, finally, retreat 1½ inch in 92 degrees, after which it will dwell for the remainder of the cycle. In Fig. 1 it is seen that the roller *A* is located at one-third of the distance from the pivot of the lever to its head. Hence a movement of one-half inch is required of the roller in the cam to move the lever head 1½ inch.

Layout of Cam.

We will now begin the layout. Draw first the circumference of the cam; its diameter we will make 10 inches. With the keyway on the vertical diameter, draw a line through its center. With this line as zero, divide the circumference into 30 degree sections, as shown, and number them. Now draw the circle *D* with a radius of 4 3/16 inches, to show the extreme outer position of the center of the roller, and the circle *E* with a radius of 3 11/16 inches, to show the extreme inner position of the center of the roller. Next, with the center of the cam as its center, draw the circle *F*, so that it will pass through the center of the stud *C*. Beginning with the center of the stud *C* as zero, divide this circle into sections and number them, as shown, for each 60 degrees. Such further sub-divisions as may be needed later may be made when required.

Proceed now with care to place the needle of a pair of good compasses in the center of the roller *A*, and adjust them so that the pencil point will pass through the center of the stud *C*. We will call this radius *R*. Now having in mind the requirements stated above, one being that the cam should turn 150 degrees from its zero before the roller moves, place the end of the compasses at 150 degrees on the circle *D*. Holding the needle here, with the radius *R* draw an arc intersecting the stud circle *F* at the point *G*. It is seen that the point of intersection is at 60 degrees on the circle *F*. Now place the needle point 43 degrees further along on the stud circle, or at 103 degrees, and with the radius *R* draw an arc intersecting the circle *E* at the point *H*. The point *H* marks the halt of the advance of the roller, and the beginning of its dwell. Now move the needle 35 degrees further along the stud circle to 138 degrees, and with the radius *R* draw another arc intersecting the circle *E* at the point *I*. This point marks the end of the dwell and the beginning of the retreat. Now move the needle 92 degrees further along the stud circle to 230 degrees and with the radius *R* draw an arc intersecting the circle *D* at the point *K*. This point marks the end of the retreat and the beginning of the dwell for the remainder of the cycle.

The points *H*, *I* and *K* being marked, draw radii through them extending to the circumference of the cam circle. Knowing that the roll begins to advance at 150 degrees on the cam, the advance is seen to continue for 45 degrees. The roll then dwells for 35 degrees and retreats in 90 degrees, after which it dwells until the next advance begins. It is proper that these figures do not agree with the figures for the lever movement stated above. Barring possible slight errors in the layout, they are correct for the cam.

The radius of the inner wall of the raceway or groove is, of course, ½ inch less than that of the path of the cam center. Hence the radius of the inner wall of the outer dwell

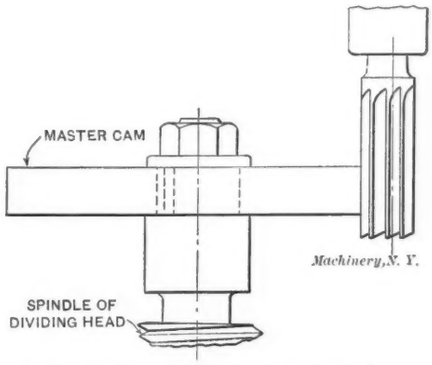

Fig. 2. Common Method of Milling Master Cams.

is 3 11/16 inches, and that of the inner dwell is 3 3/16 inches. This inner wall is the counterpart of the master cam which will be used to cut the cam groove.

Common Method of Making Master Cams.

Assuming that the master cam has been properly machined and roughed down, we will consider briefly the generally used method of finishing it. This method comprises mounting the master cam in the dividing head of a universal milling machine, and gearing the head with the feed-screw of the table so that the table will advance in proper ratio with the turning of the work in the dividing head. In Fig. 2 the master cam is mounted as above described, and held against a cutter in the vertical spindle milling attachment on a milling machine. This cutter is of the same diameter as the roll which will be used in the cam.

The process is as follows: Feed the work against the cutter until the cutter is 3 11/16 inches from the center of the master cam. Now, with the key-slot of the master cam which is the "zero" of the cam, directly in line with the cutter, turn the work 150 degrees. This finishes a part of the outer

* For additional information on this subject, see "Laying Out Cams for Rapid Motions," February, 1908, and other articles there referred to.

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dwell of the cam. The next operation is to feed the work against the cutter ½ inch while the dividing head turns 45 degrees. Since 45 degrees is ⅛ of 360 degrees, or one turn, we want gears which will turn the work ⅛ of a revolution while the table advances ½ inch. This is equal to one turn of the work while the table advances 4 inches. The gears on a feed-screw with four threads per inch, and 40-tooth worm-gear in the dividing head are,

Gear on worm 36,
First gear on stud 36,
Second gear on stud 28,
Gear on screw 70.

Having connected these gears with care, feed the work against the cutter 0.500 inch. The gears will at the same

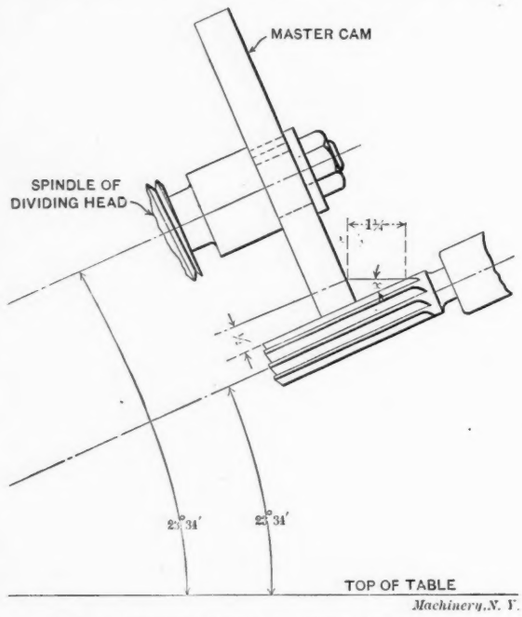


Fig. 3. Improved Method of Milling Master Cams.

time turn the work 45 degrees. This will give the advance of the cam. Now, with the table clamped where it is, turn the work 35 degrees further. This will give the inner dwell of the cam. Now change the gears so that the work will turn 90 degrees while the table is backed away ½ inch. This may be done by removing the first gear on the stud with 36 teeth and replacing it with a 72-tooth gear. Having done this with care to avoid disturbing the work during the change, back the work away from the cutter 0.500 inch. The gears will have turned the work 90 degrees more, the intermediate having been properly adjusted. This will give the retreat of the cam. Now, with the table clamped where it is, turn the work until the cutter reaches the part already finished.

This method, which has just been described, is very convenient when the change gears will give the combinations that are necessary, but it will often happen that the desired combination cannot be made with even an approach to accuracy. This difficulty may be overcome, however, by a method which is not in general use, but by which any desired result may be obtained.

Improved Method for Producing Master Cams.

For convenience we will suppose that the master cam could not be cut with the gears named or with any others, in the vertical position. We will proceed as follows: Mount the roughed out master cam as before in the dividing head, and place a 1-inch end mill in the vertical milling attachment, but, instead of setting them in a vertical position, incline each at an angle of 23 degrees 34 minutes, as shown in Fig. 3. The reason for this will appear later.

By inspection we see that if the work be fed against the cutter, Fig. 3, the cutter will enter the work and approach the mandrel. We also see that if the angle of inclination be increased or reduced, the rate with which the cutter approaches the mandrel will vary likewise. A convenient combination of gears to use in this case is one which will turn the work 360 degrees while the table advances 10 inches. This result may be obtained by using four 36-tooth gears to turn the work.

Having milled the master cam for the first 150 degrees to a radius of 3 11/16 as before mentioned, we must find the correct distance to feed the table forward in order to make the cutter approach the mandrel ½ inch while the work turns 45 degrees. The computation is done as follows: Forty-five degrees is ⅛ of 360 degrees. Since the table is geared to advance 10 inches while the work turns 360 degrees, the table will advance ⅛ of 10 inches while the work turns 45 degrees. Thus the advance is 1¼ inch to the 45-degree turn of the work. By inspection we see that in Fig. 3 the cutter and the work-face form two sides in a right angle triangle with a hypothenuse of 1¼ inch and one side of ½ inch. By solving, we find the angle α to be 23 degrees 34 minutes, as mentioned above. Having now properly connected the gears to mill the advance on the cam, feed the table ahead 1.250 inch. As just stated, this will make the cutter approach the mandrel ½ inch while the gears will have turned the work 45 degrees. Now with the table clamped where it is, turn the work 35 degrees more. We are then ready to begin the retreat of the cam. We must arrange gears which will turn the work 90 degrees while the table is backed 1¼ inch. By removing the 36-tooth gear from the screw and replacing it with a 72-tooth gear, we get this result. Carefully make the change so as not to disturb the work, and then back the table 1.250 inch. The gears will have turned the work 90 degrees further. Now, with the table clamped where it is, turn the work until the master cam is completed.

This system for making cams may be used only where uniform movements are required. While we have used it to entirely finish a master plate cam, any part of any cam requiring uniform motion may be milled in this way with a degree of accuracy not readily obtained in any other way.

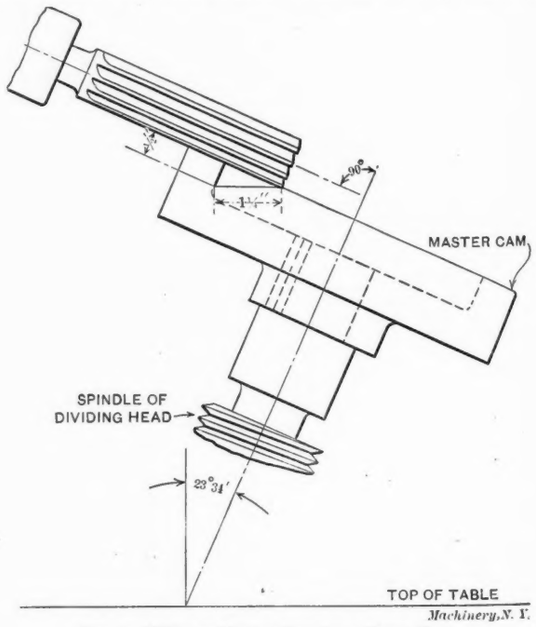


Fig. 4. Milling a Master Cam for a Drum Cam.

In fact, the work should be as true as the machine on which it is done. The same system may be used to make a master cam for a drum cam, as shown in Fig. 4. Note, however, that the work is set 23 degrees 34 minutes from the vertical position, while the cutter inclines at right angles to, instead of parallel with, the axis of the mandrel. The same combinations of gears would be used if the drum cam action were similar to the one which we have discussed. The exceedingly low cost of making master cams by this method makes it profitable to provide a master cam for cutting the groove in a single cam.

Special Cutter for Finishing Grooved Cams.

A source of constant annoyance in milling grooves in cast iron cams lies in the fact that finishing cutters quickly wear and become under size. They must then be laid aside

or used for taking the roughing cuts, while a new cutter of full size is used for finishing. We will not discuss the practice of putting a piece of paper in the collet to make the small cutter run out of true. Another source of trouble, even with cutters with spiral flutes, is the tendency of the cutter to chatter, unless it is perfectly ground and all other conditions are exactly right. Still a third trouble is in the tendency of the cutter to cut more on one side than on the other and to dig out stock in spots in the groove.

In Fig. 5 is shown an extremely simple tool, the usefulness of which cannot be overestimated for finishing grooves in cast iron cams. It is a piece of tool steel, suitably machined to mount on an arbor. It is turned on the outside, with enough stock left on for grinding, after which the spiral grooves

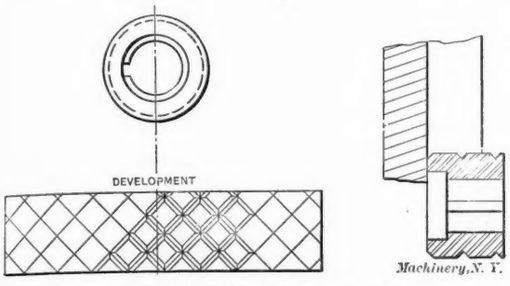


Fig. 5. Special Finishing Cutter for Cam Grooves.

shown in the developed surface are milled with an angular cutter. The piece is then hardened and ground to size. The cam groove which we are to finish is roughed out from 0.002 inch to 0.012 inch below size; the roughing cutter is removed from the spindle of the cam-cutting machine, and this special tool is mounted in its place. The cam is then fed against the tool until the tool reaches the bottom, when the cam is turned one complete revolution. The tool will leave a true groove exactly the right size, and without chatter marks or hollows.

By reason of the form of the cutting or scraping edges, it will outlast many ordinary cutters. Used in connection with it, a single roughing cutter may be repeatedly sharpened before it becomes too small for good results.

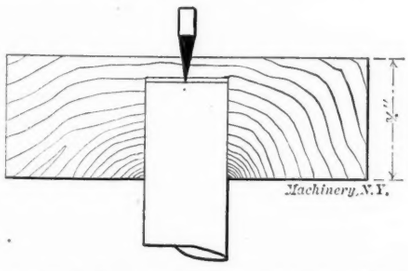
* * *

TO FIND THE CENTER OF A SHAFT.

The ways of amateurs are interesting—and sometimes instructive. The machinist will find the following question and answer, clipped from the column of a worthy contemporary, whose name we forbear to publish, interesting, somewhat amusing, but scarcely instructive, however—that is from a practical standpoint. Imagine a mechanic with a tool box filled with auger bits of various diameters for boring blocks of wood so that he could center all sizes of shafts likely to come his way! Following is the sketch with the question and answer referred to:

What is a good method for finding the center of a shaft?—A. G.

In a block of wood three-fourths inch thick bore a hole with an augur bit, just the size of the shaft. Allow the point



of the bit to just show through the block. Place the block over the end of the shaft, and the center may then be marked with a sharp pointed prick punch.

* * *

The Cincinnati Shaper Co., Cincinnati, O., informs us that it has a patent pending on its shaper key-seating attachment illustrated and described in our September issue.

ELECTRO-CHEMICAL CLEANING BATHS.

In a paper presented before the American Brass Founders' Association, by Mr. Charles H. Proctor, Arlington, N. J., the electrolytic process of cleaning metals was described. The process is comparatively new, the first published account of it appearing about three years ago, and, although used by many large concerns, it is not as generally known as it should be, considering the good results obtained and the cheapness of the process.

Alkaline substitutes, such as sodium carbonate, potassium carbonate, potassium hydroxide and sodium hydroxide in solution in varying degrees of concentration, and with small portions of potassium cyanide, develop sufficient hydrogen, with a current of 4 to 8 volts, with the bath at nearly boiling temperature, to entirely remove all organic substances from the surface of metal, leaving same chemically clean. The use of this method has been constantly increasing, and at the present time very few large concerns, particularly those engaged in the manufacture of hardware, are without electrochemical cleaning baths.

The action of an electro-cleanser is similar to the action of an electroplating bath. The only difference as far as the development of gases is concerned, is that no metal being in solution and the anode being insoluble, no metal is deposited; but with a strong current a copious evolution of oxyhydrogen gas is developed upon the articles, which attack the organic matter upon the surface, practically lifting it off and by rapid evolution of the gases carries it to the surface. The small quantity of potassium cyanide contained in solution absorbs the slight oxidation that might be upon the surface, and by the combined action produces a surface clean enough, after washing in clear water, for any deposits.

The arrangement of an electro-cleaning bath is very simple. Prepare a wrought iron tank of proportions best adapted to the amount of work to be cleansed. This should be heated with steam coils of iron. Across the top of the tank an insulated frame should be constructed. Upon this frame place three conducting poles, as on the regular plating bath. To the two outside poles the positive current should be carried direct. This can best be accomplished with at least ½-inch copper wire flexible cables. To the center pole the negative current is connected with a cable of the same dimensions; no rheostats are necessary. The stronger the current the greater the evolution of gases and the quicker the cleansing operation is accomplished.

Although direct contact can be made with the positive current to the tank itself, in practice better results have been obtained with anodes of sheet iron not more than 6 inches wide and of a length in proportion to the depth of the tank.

The electro-cleaning solution should consist (for ordinary purposes) of 3 to 4 ounces caustic potash to each gallon of water, and to every 100 gallons of solution 8 ounces cyanide of potassium. This can be varied according to conditions. It is advisable to add at least ¼ pound of cyanide each week. Where the articles, such as iron or steel, contain much oil or grease upon the surface, the density of the solution can be increased. For articles of brass, copper or bronze that have been polished, use a solution of carbonate of soda in the proportion of 2 ounces soda and ½ ounce caustic potash to each gallon of water, with the addition of 4 ounces of cyanide to every 100 gallons of solution. If much organic matter is upon the surface of the articles to be cleansed, it is advisable, where an air pressure can be obtained from an ordinary blower, to arrange a pipe so that the current of air can be deflected upon the surface of the solution, thus keeping the center of the solution clear of the insoluble substance that arises to the surface. When the cleanser is at rest, as much of this matter as possible should be removed.

It should be the aim of the operator to use the same methods of avoiding all unnecessary contamination as he would in electro-depositing baths. It is obvious even to those who have not practiced this method of cleansing metallic articles that large quantities of work can be treated very rapidly, and this is the case especially where frames or racks are used in the plating operations.

CABLE HAULING ON THE NEW MANHATTAN BRIDGE.

From the windows of the Industrial Press business office the construction of the new Manhattan Bridge, spanning the East River, can be plainly seen. This is the fourth great bridge joining Manhattan and Long Island, the others being the well-known suspension form. The towers of the Manhattan Bridge are built of structural steel and were completed a few months ago. At the present time the process of "spinning" or hauling the cables is going on. Preliminary to spinning the cables, temporary foot-bridges were erected, these being suspended on 1¾-inch cables. These cables support

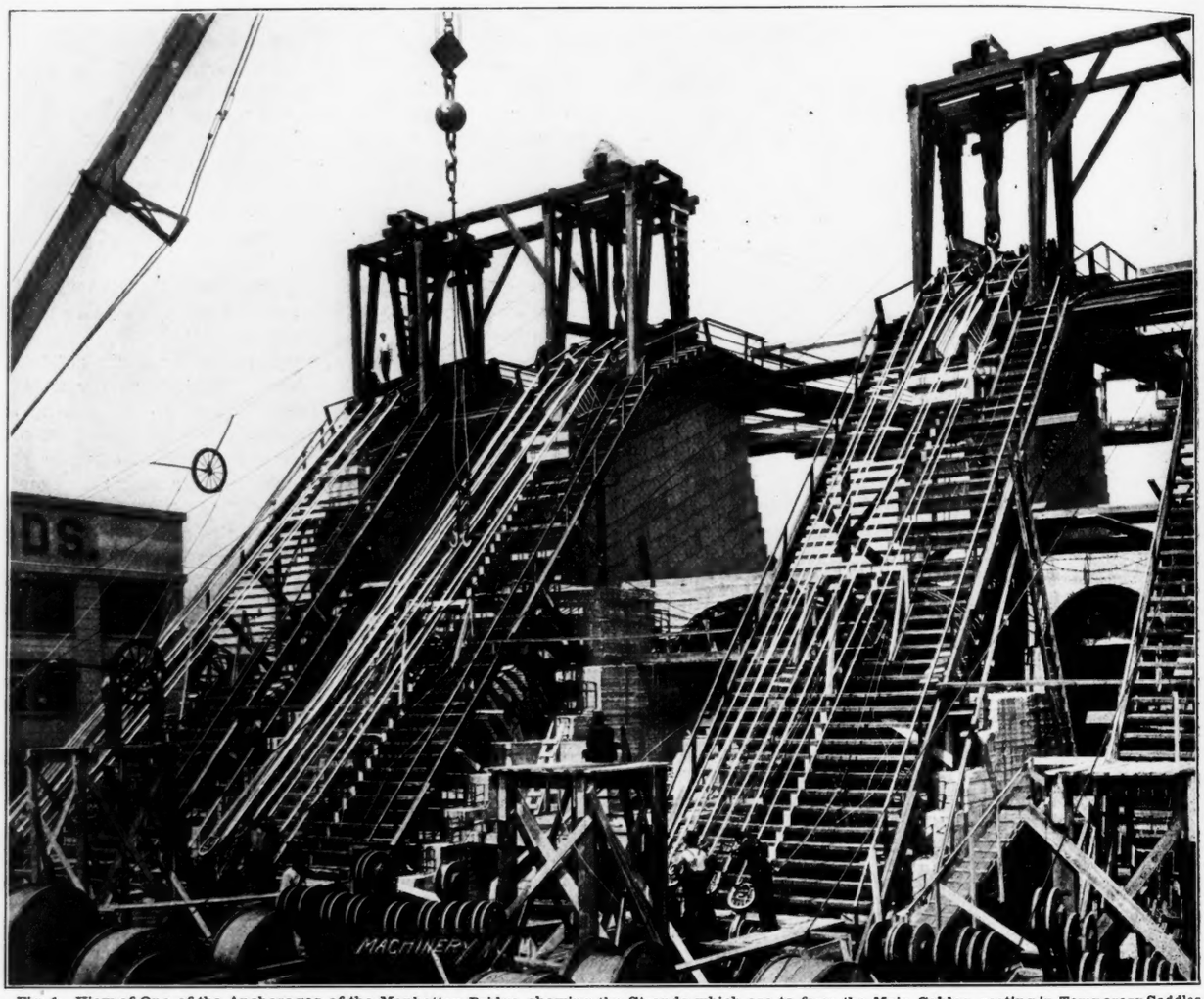


Fig. 1. View of One of the Anchorages of the Manhattan Bridge, showing the Strands which are to form the Main Cables, resting in Temporary Saddles.

Fig. 2. One of the Sheaves used for Hauling the Small Steel Cable Wires across the River.

Fig. 3. View of the Temporary Foot-bridges which Support the Hauling Cables.

the Brooklyn Bridge and Williamsburg Bridge, both completed, and the Blackwell's Island Bridge, nearly finished. The latter is of the cantilever type, and the other three are of four foot-bridges on which the workmen stand, and also sustain the hauling rope supports which guide and control the spinning of the wire composing the four main

cables. Each cable will contain 37 strands of 256 wires each, a total of 9,472 wires per cable, which must be strung wire by wire. The enormous amount of work involved will be done by machinery driven by electric motors.

The stringing of the wires in each cable is accomplished by means of two traveling sheaves carried on opposite legs of an endless steel rope. Each sheave consists of a three-foot grooved wheel fastened to the hauling rope by means of

Each hauling rope is driven by a 50-H.P., 220-volt Crocker-Wheeler form W motor. This is the type of motor designed by the Crocker-Wheeler Company for rolling mill duty, and is well adapted to work of this kind where sudden overloads and frequent starting and stopping are likely. The motors are fully enclosed and capable of withstanding all kinds of weather and rough handling. The driving mechanism is shown in Figs. 4 and 5. Each motor is geared to a counter-

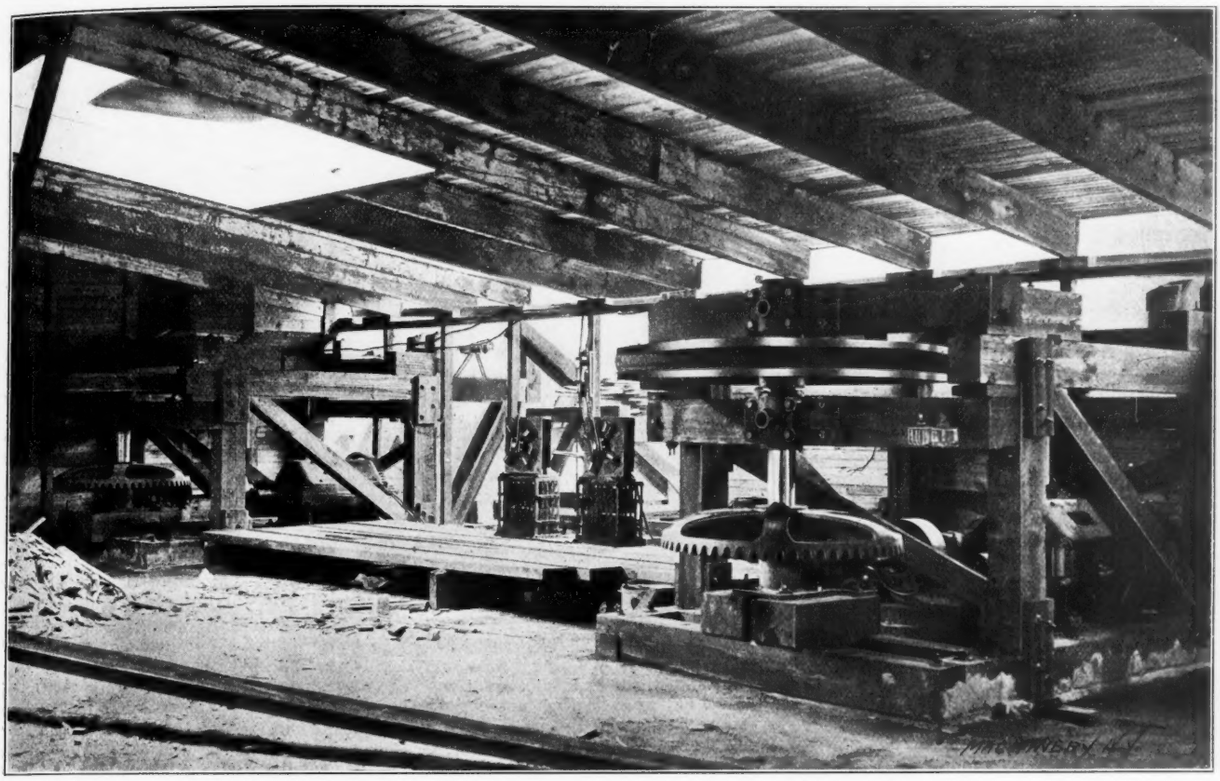


Fig. 4. Cable Hauling Machinery, Brooklyn Anchorage Manhattan Bridge.

wrought iron brackets, as shown in Fig. 2. The hauling rope is three-quarters inch diameter, and runs above the position of the bridge cables on heavy rollers supported on uprights on the temporary foot-bridge. See Fig. 3. There are five of these hauling rope supports on the center span, two on each end span and one on each tower. The hauling sheaves move back and forth across the bridge from anchorage to anchorage, a distance of 3,223 feet. They are attached one to each leg of the hauling rope so that they move in opposite directions.

The wire, which is 0.192 inch in diameter (No. 6 Roebling gage), is delivered to the bridge on enormous reels or spools, weighing three tons each. Half of these reels are placed at each end of the bridge. The end of the wire from a reel at each end of the bridge is put over the hauling sheave at that end and fastened to the anchorage. The machinery is then started and the sheaves move across the bridge, unwinding one wire from each reel. Two wires are thus strung by each sheave every time it crosses the bridge. When the sheave reaches the opposite side of the bridge the bight of the wire is taken off and made fast to that anchorage, and a new wire hauled from that side on the return trip.

The wires are laid in temporary saddles of four grooved pulleys at each anchorage. See Fig. 1. As the hauling of each strand of 256 wires is completed, the wires are bound together at intervals, and the strand is lifted from the temporary saddle by means of a chain hoist and laid in its proper place in the permanent saddle. Two strands of each cable are strung simultaneously by the two sheaves of each hauling rope.

There is a separate hauling mechanism for each of the four bridge cables, so that they are strung independently of each other. Delays are, therefore, not cumulative. The delays in one cable affect that cable alone, and the work proceeds on the others. This results in a very considerable saving of time.

shaft at a ratio of 5 to 1, and the counter-shaft is bevel geared to the driving shaft at a 5 to 1 ratio. On the driving shaft, above the gears, is a wood-lined, grooved, six-foot traction wheel, which drives the hauling rope. A five-foot idler wheel is also provided so that the hauling rope passes the traction

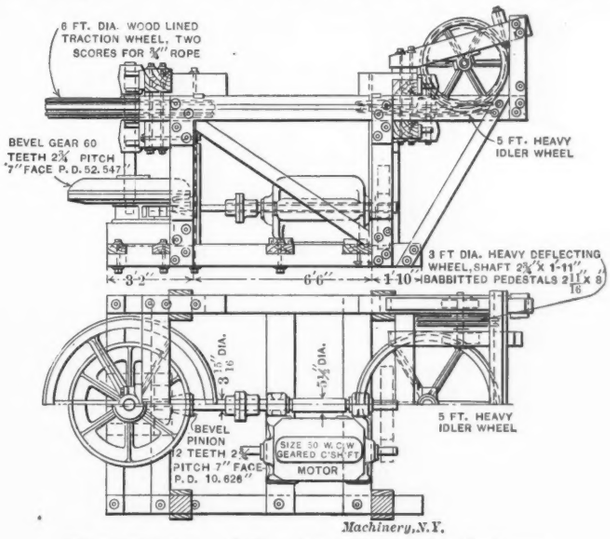

6 FT. DIA. WOOD LINED TRACTION WHEEL, TWO SCORES FOR ¾" ROPE
BEVEL GEAR 60 TEETH 2¾ PITCH 7" FACE P. D. 52.547"
5 FT. HEAVY IDLER WHEEL
3 FT DIA. HEAVY DEFLECTING WHEEL, SHAFT 2⅞" X 1-11" BABBITTED PEDESTALS 2 11/16 X 8
3'-2"
6'-6"
1-10
3 15/16 DIA.
5½" DIA.
5 FT. HEAVY IDLER WHEEL
BEVEL PINION 12 TEETH 2¾ PITCH 7" FACE P. D. 10.626"
SIZE 50 W. C. W. GEARED C'SK. FT.
MOTOR
Machinery, N.Y.

Fig. 5. Elevation and Plan of the Cable Hauling Machinery.

wheel twice, to produce the necessary grip. The driving motors are all located on the anchorage at the Brooklyn end of the bridge.

The hauling rope moves at a speed of approximately 480 feet per minute. It carries the sheaves across the river in about seven or eight minutes. Allowing for the time used in attaching wires at each end, about three trips are made per hour. It is estimated that at this rate the work of hauling

will occupy four months, some time being consumed in fixing guide wires for each strand and in adjusting the wires after they are hauled.

The reels of wire, as already stated, are stored at both ends of the bridge. The wire was delivered by John A. Roebling's Sons Co., the same firm which delivered the wire for the old Brooklyn Bridge thirty years ago. The work of building the cables is being carried on by the Glyndon Contracting Co., of New York City.

The hauling equipment for this bridge differs from any previously used. It will be remembered that in hauling the cables for the Williamsburg Bridge two steam engines were used, connected to the same driving shaft. It later became necessary to cut this shaft and use the engines independently to avoid cumulation of delays. Even with that arrangement only two cables could be hauled simultaneously. The Glyndon Company's cable hauling plant has doubled the capacity, and besides being electrically- instead of steam-driven, it is easier of manipulation and control.

* * *

FITCHBURG COOPERATIVE INDUSTRIAL SCHOOL COURSE.

The Fitchburg Iron Workers' Association, Fitchburg, Mass., recently tendered a banquet to the members of the Fitchburg city government and school board, and laid before them the plans for an industrial school to be incorporated in the present high school system, which was readily taken up by the city government, and has been put into operation.

The idea is somewhat unique, and bids fair to become an essential factor in industrial education in towns and cities of limited size throughout the country. The plan, as outlined, is in a form of an apprenticeship system whereby boys having passed the first year in high school, take up during three years, a mechanical course studying one week in the school, and the following week working in the shops. A special instructor has been employed, and special text-books provided. The boys are taken in pairs by the manufacturing companies, and the boy who has studied in school a week, on Saturday morning at 11 o'clock goes to the shop and learns on what particular job the other boy has been working, and how it is handled, so that he can come in the following Monday morning and begin work where his mate left off, thus following the shop course without necessitating instruction on the part of the shop foreman.

Mr. Hunter, the man in charge of this work, has had more applications than could be taken care of the first year, and at the present time all the boys are working in the shops and will continue to do so until the school opens. The cooperative industrial high school course is as follows:

FIRST YEAR, ALL SCHOOL WORK.

English	4	periods	per	week.
Shop Mathematics	5	"	"	"
Mechanics	5	"	"	"
Freehand and Mechanical Drawing	5	"	"	"
Current Events	2	"	"	"

SECOND YEAR, SCHOOL AND SHOP WORK.

English	4	periods	per	week.
Shop Mathematics	5	"	"	"
Chemistry	4	"	"	"
Electricity and Heat	4	"	"	"
Freehand and Mechanical Drawing	8	"	"	"

THIRD YEAR, SCHOOL AND SHOP WORK.

English	4	periods	per	week.
Shop Mathematics	4	"	"	"
Commercial Geography, Business Methods and Conditions	4	"	"	"
Advanced Chemistry or Industrial History	5	"	"	"
Freehand and Mechanical Drawing	8	"	"	"

FOURTH YEAR, SCHOOL AND SHOP WORK.

English	4	periods	per	week.
Civics and American History	5	"	"	"
Applied Mathematics	5	"	"	"
Mechanical and Freehand Drawing	8	"	"	"
Discussion of Current Mechanical Appliances	2	"	"	"

Shop work consists of instruction in the operation of lathes, planers, drilling machines, in bench and floor work, and in other machine work according to the ability of the apprentice as pertaining to the particular branch of manufacture in the shop where he is employed.

Copy of the rules and conditions of this system is given below:

Rules and Conditions.

Under Which Special Apprentices Taking the Four-Year Coöperative Industrial Course at the High School of Fitchburg Are Received for Instruction at the works of

Blank Machine Co.

1. The Applicant for apprenticeship under this agreement must have satisfactorily met requirements for entrance to this course at the high school.

2. The apprentice is to work for us continually, well and faithfully, under such rules and regulations as may prevail, at the works of the above company, for the term of approximately 4,950 hours, commencing with the acceptance of this agreement, in such capacity and on such work as specified below:

Lathe Work,
Planer Work,
Drilling,
Bench and Floor Work.
And such other machine work, according to the capacity of the apprentice, as pertains to our branch of manufacturing.

This arrangement of work to be binding unless changed by mutual agreement of all parties to this contract.

3. The apprentice shall report to his employer for work every alternate week when the high school is in session, and on all working days when the high school is not in session, except during vacation periods provided below, and he shall be paid only for actual time at such work.

4. The apprentice is to have a vacation, without pay, of two weeks each year, during school vacation.

5. The employer reserves the right to suspend regular work wholly, or in part, at any time it may be deemed necessary, and agrees to provide under ordinary conditions other work at the regular rate of pay, for the apprentice during such period.

6. Should the conduct or work of the apprentice not be satisfactory to employer, he may be dismissed at any time without previous notice. The first two months of the apprentice's shop work are considered a trial time.

7. Lost time shall be made up before the expiration of each year, at the rate of wages paid during said year, and no year of service shall commence till after all lost time by the apprentice in the proceeding year shall have been fully made up.

8. The apprentice must purchase from time to time such tools as may be required for doing rapid and accurate work.

9. The said term of approximately 4,950 hours (three-year shop term) shall be divided into three periods as stated below, and the compensation shall be as follows, payable on regular pay-days to each apprentice:

For the first period of approximately 1,650 hours: 10 cents per hour.

For the second period of approximately 1,650 hours: 11 cents per hour.

For the third period of approximately 1,650 hours: 12½ cents per hour.

10. The above wage scale shall begin the first day of July preceding the apprentice's entrance upon the first year of shop work of the high school industrial course.

The satisfactory fulfilment of the conditions of this contract leads to a diploma, to be conferred upon the apprentice by the school board of Fitchburg upon his graduation, which diploma shall bear the signature of an officer of the company with which he served his apprenticeship.

* * *

AN AMERICAN MECHANIC IN EUROPE.

With reference to installment No. 5 of the above series which appeared in your August issue, we find on page 909 (engineering edition) a reference to ourselves in which it is stated: "The company usually builds the machines in lots of three throughout all departments, only occasionally making a larger number at a time."

We believe the above must be a printer's error or due to a misunderstanding on the part of the author, as we informed him we built the machines in lots of *three dozen*. This applies to machines 3 feet 6 inches, and 4 feet radius, and to a number of lighter machines up to 5 feet and 6 feet radius on special classes of work. The heavy type of machines weighing from 7 to 8 tons and upwards cannot, of course, be put through in such large quantities.

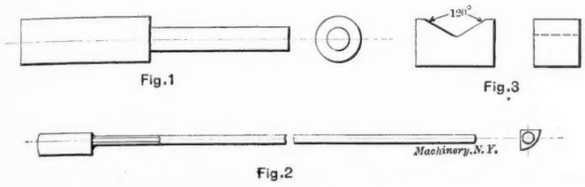
Halifax, England. WILLIAM ASQUITH, LTD.

THE STEAM HAMMER AND ITS USE.

JAMES CRAN.*

One of the greatest changes in the way of improvement in the art of blacksmithing came with the steam hammer. It made possible the making of heavy forgings from one solid piece of iron or steel, which previously had to be made in sections and welded together. Welding is still necessary on a great many kinds of blacksmith work, but with the steam hammer it can be done in less time and to better advantage than is possible by hand. The majority of people, including blacksmiths, seem to have only one conception of a steam hammer, that of a piece of machinery intended for striking a heavy blow; this is the principal, but by no means the only purpose for which it can be used. With a good equipment of tools and a good operator it is possible to do nearly any kind of machine blacksmithing—all but the finishing touches—at the steam hammer. If necessary it can also be used to do drop forging and as a trimming press, shears, bulldozer, and vise, and for a variety of other purposes.

With all its advantages it is, as a rule, one of the most abused pieces of machinery to be found around a manufacturing plant. For every other kind of machine there is usually a skilled operator. If it happens to be operated by a boy, or any one else who does not thoroughly understand



Figs. 1 to 3. Example of Work, and Tools for "Breaking Down" Forgings.

it, he is generally doing so under the directions of a competent man. For the steam hammer, as with every thing else in the blacksmith shop, anything is good enough—an ordinary laborer, a small boy, or any one who comes along, provided he can be hired for a small amount of money, regardless of safety or economy. To get the best results from a steam hammer, however, as with any other kind of machine, it is absolutely essential that the operator thoroughly understands his business. He should be as conversant with the working parts and mechanism as an engineer should be with an engine, and should be able to do all minor repairing, such as packing glands, adjusting guides, valves, etc. As a machine operator, he should be classed with skilled labor, and paid according to his ability. Like all other classes of help, really good steam hammer operators are scarce from the fact that the unskilled laborer usually gets the same rate of wages.

The purpose for which the steam hammer is principally used is to draw iron or steel to smaller dimensions in the

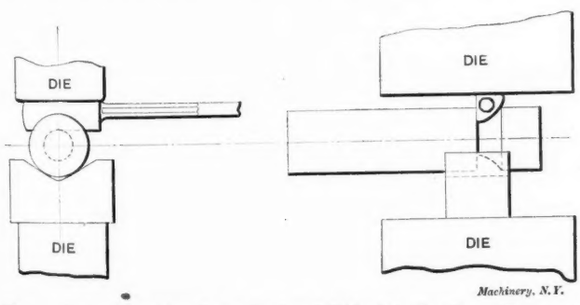


Fig. 4. Use of Breaking Down Tool and V-block in the Steam Hammer.

making of forgings. This can be done to the best advantage if the dies are slightly crowned in the center, not necessarily over 1/16 inch for each die, and the edges rounded off to about a radius of 3/32 inch. Any one who has done work with a steam hammer will appreciate the advantage of having the dies crowned. In drawing stock with perfectly level dies, the drawing is most in evidence where the edges come in contact with the metal; in the center it is simply spread out, there being nothing in the dies themselves to give it a tendency to draw when a blow is struck by the hammer. With the dies crowned, a blow will be more effective, and the spreading of stock will be reduced to a minimum. It is also an advantage to have the sides of the dies square, so that in making forgings such as are shown in Fig. 1, the shoulder will be as near as possible at right angles with the body of the piece.

In "breaking down" stock for a shoulder a tool similar in construction to Fig. 2 should be used, the head or part which

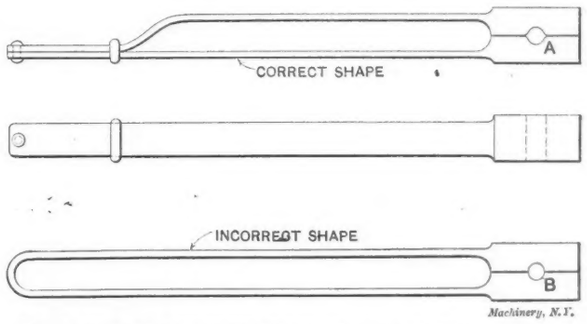


Fig. 5. Correct and Incorrect Types of Swages for Steam Hammer.

does the work being in the shape of one-quarter of a circle, with the edges slightly rounded to prevent cutting. This tool will break down a shoulder square. It can be used either right or left-hand, and its shape gives it a tendency to crowd towards the shoulder which will leave the stock at that point up to, or slightly larger than, the original dimensions. This tool presents decided advantages over the round tool commonly used, as this latter has a tendency to drag down the edges near where it is used, making it necessary to upset and finish the work by hand to get the body of the forging uniform throughout. When round stock is being broken down it is usually placed in a circular tool similar to a swage, which necessitates the using of a different tool for

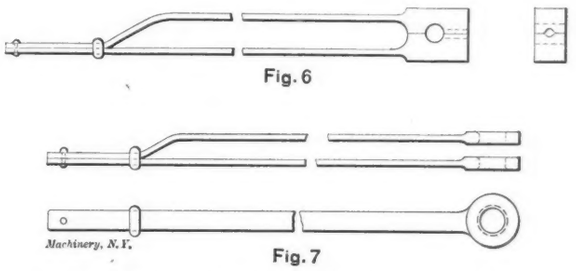


Fig. 6. Swages for Making Blank-headed Eye-bolts. Fig. 7. Swages for Forging Hubs.

each size of stock. If a tool is used of the style shown in Fig. 3, which is made in the form of a V-block with a circular bottom, it will accommodate several sizes of stock. Four or five such tools of different sizes will cover a large range of work.

Fig. 4 shows how the breaking down tool and the V-block should be used in the steam hammer. The V-block is placed upon the bottom die, the work is laid in the V-block, and the breaking down tool on top of the work at the point intended for the shoulder. The tool is guided by hand until the piece has been marked all the way around. It can then be driven in, turning the piece continually, until it has reached the required depth. In drawing the shank of a forging, such as is shown in Fig. 1, it should be kept square until it has been reduced to the required size; the corners are then worked in until an octagon shape is obtained; and, finally, the corners are rounded. This procedure prevents the center being "piped."

In finishing round work, it should be done as far as possible at the steam hammer, using spring swages. Of these there are several styles. Fig. 5 shows at the top the style which is simplest and most satisfactory to use. The swages are made in two separate parts and held together by one rivet, and provided with a band to keep them in alignment without having to use a guide pin. The impression in each

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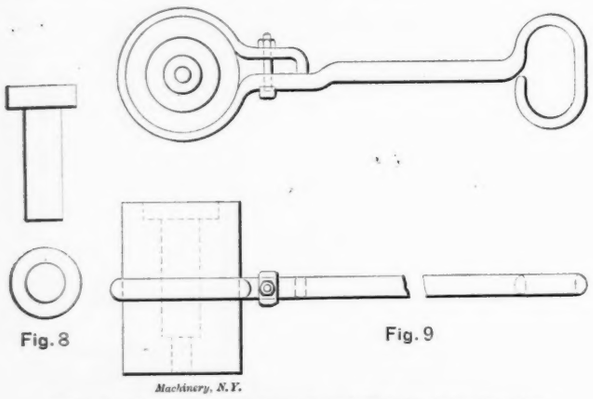
part should be half the depth of the diameter of the piece the swages are intended to finish, so that it would be impossible to swage a forging under size. The edges or lips should be well backed off to prevent a fin or flash being formed. If a fin or flash is formed upon a piece of work while it is being finished in swages or dies, it is liable to get worked into the forging when it is turned for the next blow of the hammer, forming what is known as a cold shut. This may not be noticed on the forging, but will show up when the work is machined; it is unsightly on machine steel pieces, and renders tool steel useless for all cutting purposes.

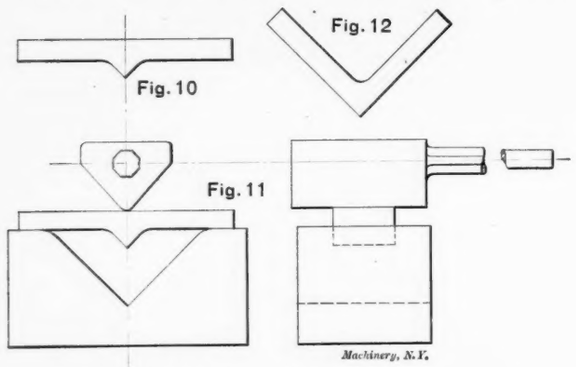
Swages of the style shown at the top in Fig. 5 can be made to form collars, ends for connecting-rods, blank-headed eye bolts, forgings with ball ends, and a variety of other pieces. No machine work is necessary on this kind of swage, as it can be made and finished complete in the blacksmith-shop by using a dummy, or a forging made as near as pos-



Figs. 8 and 9. Pin to be Forged, and Tool used for Carrying Out the Operation.

sible to the dimensions of the pieces for which the swage is intended. This sample forging is used for finishing the impression, after it has been partly worked to shape, by heating the swage, and placing the dummy in it. The swage takes its impression from the dummy in the same manner as forgings take their shape from swages or dies. This method of making tools is known as typing, and can be employed to good advantage on a great many kinds of forgings, when the quantity to be made is such that it will justify the making of tools. All forgings made in tools as here described will be duplicates and finished in less time than would be possible by hand.

Fig. 6 shows a swage for making blank-headed eye bolts, or any forging with a circular head and a plain round shank. These are different from other swages in that they have the edges of the impression sharp where the head of the forging



Figs. 10, 11 and 12. Forging an Angle Iron.

is formed to insure a perfect circle. A fin or flash may be worked out where the impressions meet, but it will do no harm as it can be trimmed off with a chisel. The edges of the part of the impression where the shank is formed should be rounded off, as a flash formed at that point would cause trouble in finishing with ordinary spring swages.

When forgings with hubs are to be made, ring swages, as shown in Fig. 7, should be used. All that is necessary is to select stock heavy enough to allow the ends of the hubs being finished. The work is heated, placed in the swage, given a few blows by the steam hammer, and the hub is formed, both sides being in perfect alignment. The stock worked out at the sides can be trimmed off with a chisel. This may seem wasteful, but the time saved will more than compensate for the loss of material. For round bosses a tool similar to half the swage, Fig. 7, should be used; or a plain ring made of round stock would answer the purpose, by being

Fig. 13. Tool for Drawing Work too short for Breaking Down under the Steam Hammer.

placed upon the stock while it is hot, and struck a few blows with the steam hammer. It may be well to explain the difference between hubs and bosses; hubs project on both sides of a forging, while bosses only project on one side.

In making forgings of the style shown in Fig. 8, it is customary to draw them from stock of larger diameter than the shank, and finish them in a heading tool. When a quantity has to be made, it is of advantage to use stock the proper size for the shank, cut in lengths, and to use a tool as shown in Fig. 9. This tool is bored out just deep enough for the length of the shank and counterbored to accommodate the head. The stock should be heated on one end, placed in the tool, a few blows given by the steam hammer, and the forging is completed. A small hole should be drilled through the bottom of the tool, so that it can be turned

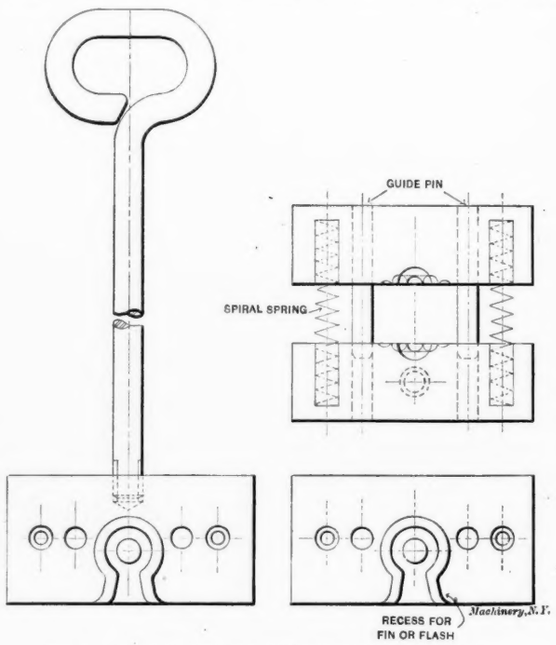


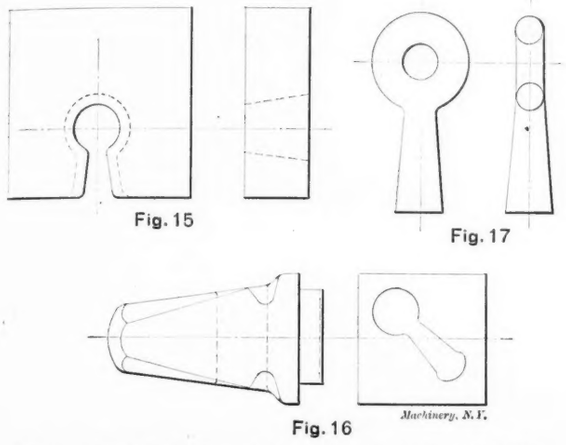
Fig. 14. Dies for Drop Forging under the Steam Hammer.

up side down, and the forging removed with a punch. Six forgings can be made in this way in the same time as it would take to make one, if drawing it from heavier stock.

In making angular forgings, stock of about the right size for the ends of the angles is usually selected, bent, and the corner worked back until it is square. This takes considerable time and careful working, or a cold shut will be formed inside the corner. With a steam hammer, pieces of this shape can be made with very little trouble by using stock heavy enough to allow a solid corner being formed as shown in Fig. 10, which can be done by using a round tool to break down each side of the piece intended for the angle, drawing the ends to the required size. Then the piece is bent in a V-block with a tool made for the purpose, as shown in Fig. 11. The result will be a piece as shown in Fig. 12. The V-block should have an included angle of 90 degrees, and be rounded at the top edges, as shown, to prevent marking the ends. The tool for bending should have the edge or corner rounded so that it will form a fillet inside the forging. Nearly any size of angle can be made with the same tools.

A tool for drawing work which is all broken down to one side, or between shoulders or bosses, when the distance is too short to reach across the dies, is shown in Fig. 13. The head is square, and the corners rounded, each to a different radius, so that fillets of different dimensions may be formed with the same tool.

Small pieces can be drop forged at the steam hammer without changing the ordinary dies, by using dies as shown in Fig. 14. The impressions are sunk the same as in regular drop forging dies. The dies are kept in alignment by two guide pins, and opened by two spiral springs placed on the guide pins. The dies are removed from the hammer dies by means of the handle attached to the back as shown. Forgings made in this style of dies are equal in every respect to regular drop forgings, with the exception that it requires more time making them. The steam hammer can be used to trim the forgings by using a trimming die and punch as shown in Figs 15 and 16. Trimming dies of the style in



Figs. 15, 16, and 17. Trimming Die and Punch, and Completed Work.

Fig 15, with open end, should be made heavy enough to prevent spreading, or breaking through the back, as they have no supporting device of the kind provided for dies in the trimming press. They also ought to be deep enough to allow of the forging dropping out of the reach of the punch when it is trimmed. Fig. 16 shows the punch, the face of which should be concaved to fit the forging it is intended to be used for. Fig. 17 shows the forging made in the dies in Fig. 14. The ends of the shanks are left heavy so that they can be finished either for eye-bolts or hooks. When made into hooks the shanks are left longer, finished in spring swages, and bent on a former made specially for that purpose. The style of dies here described can only be used for small work, and only then when the quantity is such that it will justify the expense of making the tools.

The steam hammer can be used as a punch press, when that machine is not available, by using a die and punch as shown in Fig. 18. The die is made on the same principle

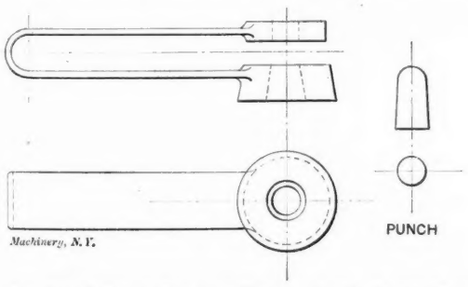
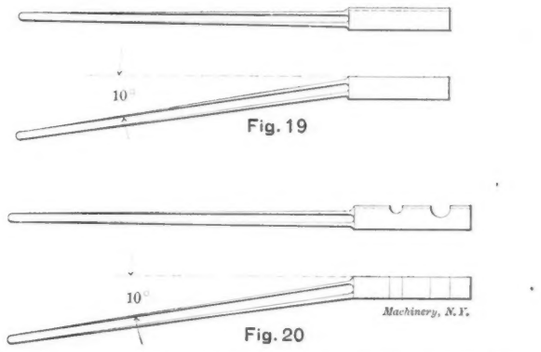


Fig. 18. Punch and Die for Punching Holes under the Steam Hammer.

as spring swages, the top part acting as a guide for the punch. The lower part, or die proper, should be thick enough to allow the scrap from the hole and the punch dropping below the level of the guide, otherwise the punch would be liable to be bent or broken. Punches need never be longer than the depth of the die, and should be tapered from the face to give them clearance when being driven through the stock. This style of die and punch can be used on hot work, as for removing the stock between the jaws of wrenches, the centers of eye-bolts when being forged by hand, etc.

In shops where there are no shears the steam hammer can be used for cutting off cold stock by using tools as shown in Figs. 19 and 20. Only one tool of each kind is shown, but the tool can, of course, only be used in pairs, one below and one over the stock, so that their edges will just pass by each



Figs. 19 and 20. Tools used under Steam Hammer for Shearing Off Stock.

other, the same as the jaws of shears. Fig. 19 shows the tools used for flat stock, while Fig. 20 shows the shape of tools for round stock. These tools are not as handy as shears, nor quite as safe, but are superior to saw or chisel in cutting up stock for forging.

In forging rings of rectangular section it is customary to use stock of about the right dimensions for the section, bend it to shape, and weld it. This is all right for small rings, or large rings with small section; but when the size exceeds 5 inches inside diameter, and the section 1¼ inch square, it is advisable to make the rings from the solid stock for several reasons, principal of which are the saving of time, a more uniform section, and a perfectly solid forging when the ring

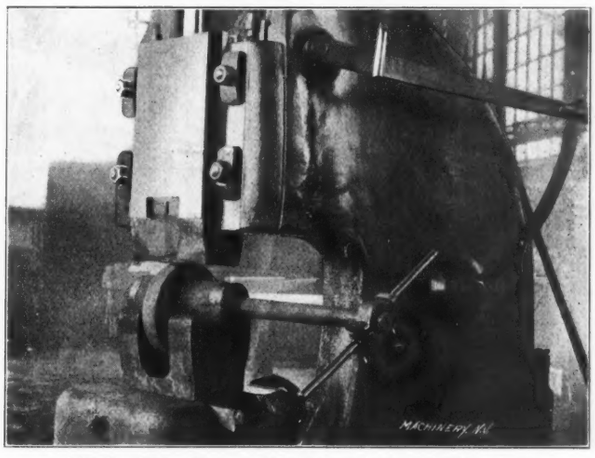


Fig. 21. Steam Hammer Fixture used when Forging Rings.

is finished. This latter is impossible with a welded ring, except at cost and labor out of all proportion with the size of the job. To begin with the ends of the stock must be upset to allow for waste in welding, and bent in the form of a circle, which distorts the shape of the material; the outside is drawn out while the inside is upset or compressed. The only part of the stock which retains its original size is the neutral line at the center of the bar. After the ring has been welded, it has to be flattened and trued up all over to get it anything like uniform. Then, there are always chances of a poor weld, which makes the finished piece useless for all practical purposes.

When rings are to be made from the solid, the first thing to be done is to find the right amount of stock to use, which can be done by consulting hand-books, or by figuring out the cubic contents of a solid piece having the same diameter and the same thickness as the ring for which it is intended, deducting the number of cubic inches equal to the hole, and allowing enough extra material for waste in forg-

ing, and for finishing in the machine shop. Cut off a piece of round stock the proper length, and upset it under the steam hammer until it is of the same thickness as the face of the ring to be forged. Punch a hole in the center, and "drift" until it is approximately of the diameter required in the finished ring. The lower die should then be removed from the steam hammer, and a fixture of the style shown in the half-tone, Fig. 21, keyed in its place. This fixture is made in the form of a double V-block, the V's being circular in the bottom, and of an angle of about 120 degrees, allowing the use of different sizes of mandrels in drawing the rings to the required size. The ring or piece of stock with the hole punched through it is then placed between the V's, and the mandrel slipped through the hole and turned by means of the handles clamped to the shank. In turning the mandrel, the ring is turned with it, bringing a different point in line with the top die for each stroke of the hammer. This is done until the proper size has been reached, using larger mandrels as the hole increases in size. Rings up to 50 pounds can be made complete in two heats. Larger rings up to the full capacity of the steam hammer can be made by using a larger fixture in the anvil block by removing the chair for the lower die. It is advisable to use hollow mandrels for the larger sizes to facilitate their handling. Rings made from the solid in the manner here outlined can be completed in one-third the time required for welded rings. The section is uniform throughout, and no poor welds or overheated spots show up in the machining.

If the steam or power hammer were used, as it should be, to do the heaviest and most difficult work, the art of blacksmithing would be made more attractive, and the manufacturers' profits would be increased.

* * *

THE GISHOLT SHOP BAND.

The Gisholt band illustrated here is an outgrowth of the Gisholt Club, a social organization of the employes of the Gisholt Machine Co., Madison, Wis. The main object of the club is to promote acquaintanceship and good fellowship among the employes and their families. A room is provided by the company in which various entertainments are given during the year, and lecturers are employed from time to time to speak on topics of general interest. An event of importance is an annual picnic held on ground across Lake Mendota, near Madison. The picnic this year took place on August 8. In all these entertainments the Gisholt band is in evidence, and its members have acquired such proficiency that it plays very good music. A pleasing feature of the club during the summer is the open-air concerts given by the band on a piece of vacant property adjoining the Gisholt works. The club organization and the band auxiliary tend to bind together the employes to work for the common good, and are in line with all sound movements for the promotion of progress in coordinating human interests and manufacturing methods.

Gisholt Machine Co. Band.

JIGS AND FIXTURES—7.

EINAR MORIN.*

EXAMPLES OF DESIGNS OF OPEN DRILL JIGS.

A typical example of an open drill jig, very similar to the one developed and explained in the September issue, is shown in Fig. 73. The work is located against the three locating pins *A*, and held in place against these pins by the three set-screws *B*. The three straps *C* hold the work securely against the finished pad in the bottom of the jig. These clamps are so placed that when the work has been drilled and the clamp screws loosened, the clamps will swing around

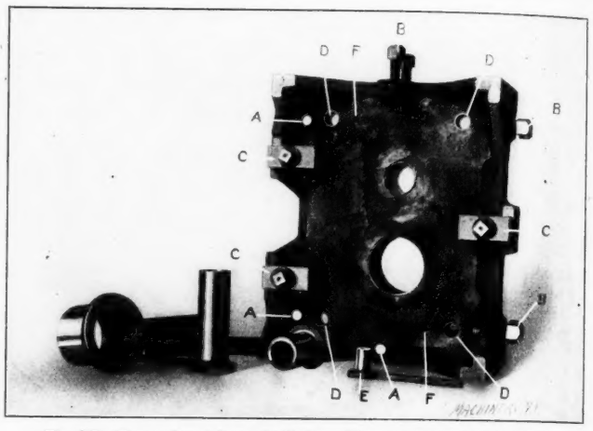


Fig. 73. Example of Open Drill Jig. View showing Front Side.

a quarter of a turn, allowing the work to be lifted directly from the jig and a new piece of work inserted, when the clamps are again turned around into the clamping position, and the screws tightened. These straps are integral parts of the jig; at the same time, they are quickly and easily manupulated, and do not interfere with the rapid removal and insertion of the work. The strength and rigidity of the feet in proportion to the jig should be noted, this strength being obtained by giving proper shape to the feet, without using an unnecessary quantity of metal.

The jig in Fig. 73 is also designed to accommodate the component part of the work when it is being drilled. When this is done, the work is held on the back side of the jig, shown in Fig. 74. This side is also provided with feet, and has a finished pad against which the work is held. The locating pins extend clear through the central portion of the jig body, and, consequently, will locate the component part of the work in exactly the same position as the piece of work being drilled on the front side of the jig. The same clamping straps are used, the screws being simply put in from the opposite side into the same tapped holes as are used when clamping on the front side of the jig. The four holes *D* are guide holes for drilling the screw holes in the work, these being drilled the body size of the bolt in one part, and the tap drill size in the component part. The lining bushing in the holes *D* serves as a drill bushing for drilling the body size holes. The loose bushing *E*, Fig. 73, is used when drilling the tap holes in the component part, the inside diameter of this bushing being the tap drill size, and the outside diameter a good fit in the lining bushing. The two holes *F*, Fig. 74, are provided with drill bushings and serve as guides when drilling the dowel pin holes, which are drilled below size, leaving about 0.010 inch, and are reamed out after the two component parts of the work are put together. The two holes shown in the middle of the jig in Fig. 73, and which are provided with lining bushings, and also with loose bushings, as shown inserted in Fig. 74, may be used for drilling and reaming the bearing holes for the shaft passing through the work. In this particular case, however, they are only used for rough-drilling the holes, to allow the boring-bars to pass through when finishing the work by boring in a special boring jig, after the two parts of the work have been screwed together.

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The large bushings shown beside the jig in Fig. 73 are the loose bushings shown in place in Fig. 74. It will be noted that the bushings are provided with dogs for easy removal, as explained in the installment in the May issue, and illustrated in Fig. 11. As the central portion of the jig body is rather thin, it will be noticed in Fig. 74 that the bosses for the central holes project outside of the jig body in order to give a long enough bearing to the bushings. This, of course, can be done only when such a projection does not interfere with the work. The bosses, in this particular case, also serve another purpose. They make the jig "fool-proof," because the pieces drilled on the side of the jig shown in Fig. 73 cannot be put on the side shown in Fig. 74, the bosses preventing the piece from being placed in position in the jig.

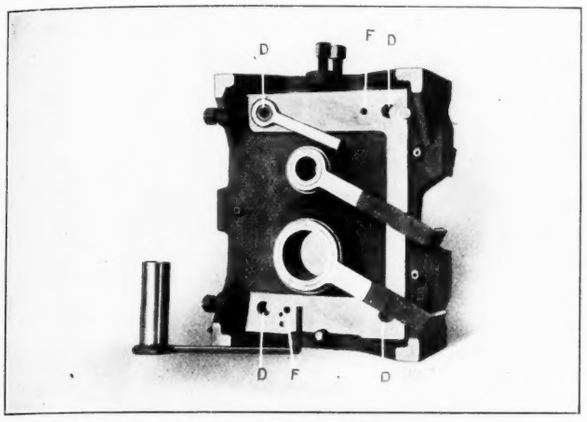


Fig. 74. Rear View of Drill Jig shown in Fig. 73.

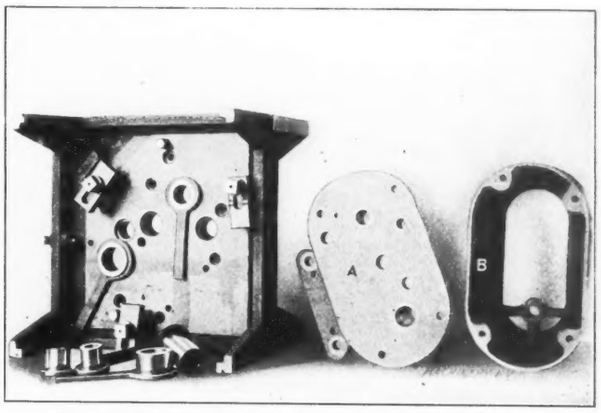


Fig. 75. Drill Jig used for Drilling Work shown to the Right.

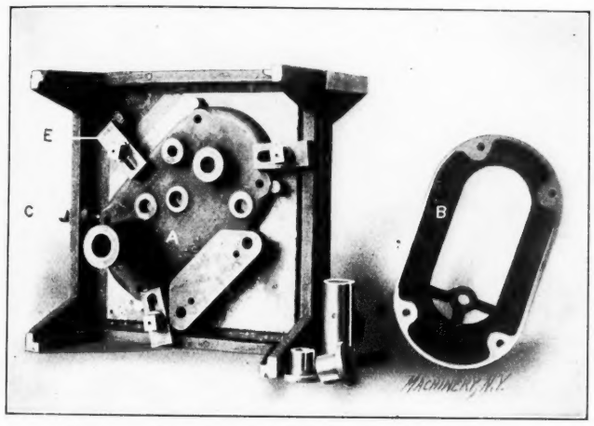


Fig. 76. Drill Jig shown in Fig. 75 with Work in Place.

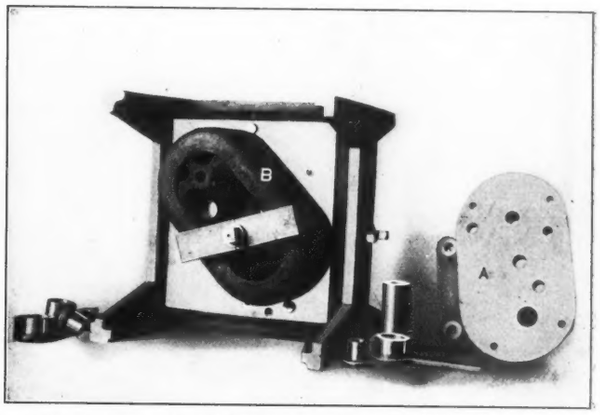


Fig. 77. Rear View of Drill Jig shown in Fig. 75, with Cover to be Drilled in Place.

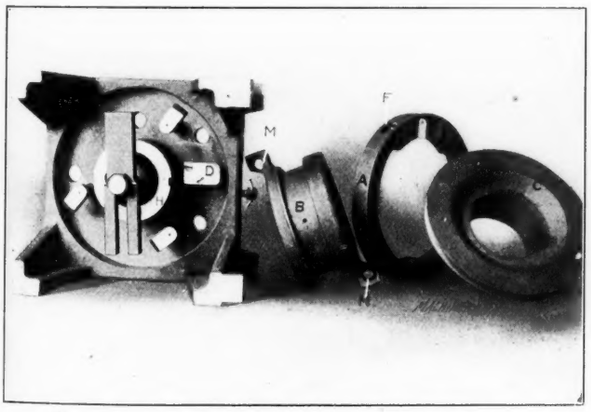


Fig. 78. Drill Jig for Parts of Friction Clutches which are shown at the Right.

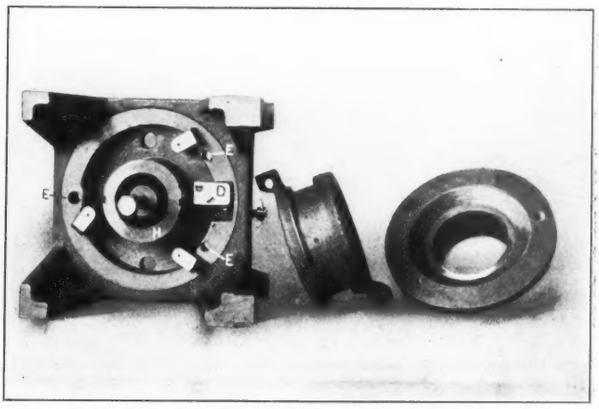


Fig. 79. Drill Jig shown in Fig. 78, with one of the Pieces to be Drilled in Place.

Attention should be called to the simplicity of the design of this jig. It simply consists of a cast iron plate, with finished seats, and feet projecting out far enough to reach below the work when drilling, three dowel pins, set-screws for bringing the work up against the dowel pins, three clamps, and the necessary bushings. The heads of all the set-screws and bolts should, if possible, be made the same size, so that the same wrench may be used for tightening and unscrewing all of them. It can also be plainly seen from the half-tones that there are no unnecessarily finished surfaces on the jig, a matter which is highly important in economical production of tools.

Another example of an open drill jig, similar in design to the one just described, is shown in Fig. 75. The work to be drilled in this jig is shown at *A* and *B* at the right-hand side of the jig. In this case, the work is located from the circular ends. The two pieces *A* and *B* are component parts, and when finished are screwed together. The piece *A* is located against three dowel pins, and pushed against them by set-screw *C*, and held in position by three clamping straps, as shown in Fig. 76. In this case, the straps are provided with oblong slots as indicated, and when the clamp screws are loosened, the clamps are simply pulled backward, permitting the insertion and removal of the work without interference. It would be an improvement on this clamping arrangement to place a stiff helical spring around the screws under each strap, so that the straps would be prevented from falling down to the bottom of the jig when the work is removed.

At the same time this would prevent the straps from swiveling around the screws when not clamped.

In Fig. 77, the part *B* in Fig. 75 is shown clamped in position for drilling, the opposite side of the jig being used for this purpose. In jig design of this kind it is necessary to provide some means so that the parts *A* and *B* will be placed each on the correct side of the jig, or, as said before, the jig should be made "fool-proof." In the present case, the parts cannot be exchanged and placed on the wrong side, because the cover or guard *B* could not be held by the three straps in Fig. 76, on account of the screws for the straps not being long enough. On the other hand, the piece *A* could not be

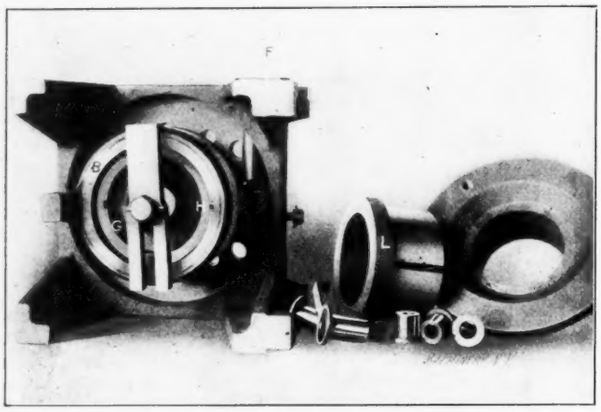


Fig. 80. Drill Jig shown in Fig. 78 used for Drilling Friction Sleeve.

placed on the side shown in Fig. 77, because the long bolt and strap used for clamping on this side would interfere with the work.

It may appear to be faulty design that three straps are used to fasten the piece *A* in place, and only one is employed for holding piece *B*. This difference in clamping arrangement, however, is due to the different number and the different sizes of holes to be drilled in the different pieces. The holes in the piece *A* are larger and the number of holes is greater, and a heavier clamping arrangement is, therefore, required, inasmuch as the thrust on the former is correspondingly greater, the multiple spindle drill being used for drilling the holes. If each hole were drilled and reamed individually, the design of the jig could have been comparatively lighter.

In the design shown, the locating of each piece individually in any but the right way is also taken care of. The piece *A*, which is shown in place in the jig Fig. 76, could not be swung around into another position, because the strap and screw at *E* would interfere. For the same reason the cover or guard *B* could not be located except in the right way. As shown in Fig. 77, the strap and screw would have to be detached from the jig in order to get the cover in place, if it were turned around. The locating pins for the work pass clear through the body of the jig, and are used for locating both pieces. The pieces are located diagonally in the jig, because, by doing so, it is possible to make the outside dimensions of the jig smaller. In this particular case the parts are located on the machine to which they belong, in a diagonal direction, so that the additional advantage is gained of being able to use the same dimensions for locating the jig holes as are used on the drawing for the machine details themselves. This tends to eliminate mistakes in making the jigs as well.

Sometimes, when more or less complicated mechanisms are composed of several parts fitted together and working in relation to each other, as, for instance, friction clutches, one jig may be made to serve for drilling all the individual parts, by the addition of a few extra parts applied to the jig when different details of the work are being drilled. In Figs. 78, 79, and 80, such a case is illustrated. The pieces *A*, *B*, and *C*, in Fig. 78, are component parts of a friction clutch, and the jig in which these parts are being drilled, is shown in the same figure, to the left. Suppose now that we wish to drill the friction expansion ring *A*. The jig is bored out to fit the ring before it is split, and when it is only rough-turned, leaving a certain number of thousandths of an inch for finishing. The piece is located, as shown in Fig. 79, against the steel block *D* entering into the groove in the ring, and is then held by three hook-bolts, which simply are swung around when the ring is inserted or removed. The hook-bolts are tightened by nuts on the back side of the jig. Three holes marked *E* in Fig. 79, are drilled simultaneously in the multiple spindle drill, and the fourth hole *F* (see Fig. 78), is drilled by turning the jig on the side. The steel block *D*, Fig. 79, is hardened, and has a hole to guide the drill when passing through into the other side of the slot in the ring. The block is held in place by two screws and two dowel pins.

When drilling the holes in the lugs in the friction sleeve *B*, Fig. 78, the block *D* and the hook-bolts are removed. It may be mentioned here, although it is a small matter, that these parts should be tied together when removed, and there should be a specified place where all the parts belonging to a particular jig should be kept when not in use. The friction sleeve *B* fits over the collar *G*, Fig. 80. This collar is an extra piece, belonging to the jig, and used only when drilling the friction sleeve; it should be marked with instructions for what purpose it is used. The collar *G* fits over the projecting finished part *H* in the center of the jig, and is located in its right position by the keyways shown. The keyway in the friction sleeve *B*, which must be cut before the piece can be drilled, and placed in the right relation to the projecting lugs, locates the sleeve on the collar *G*, which is provided with a corresponding keyway. A flange on the collar *G*, as shown more plainly at *L* in Fig. 80, locates the friction sleeve at the right distance from the bottom of the jig, so that the holes will have a proper location sideways. Two collars, *G* and *L*, are used for the same piece *B*, this being necessary because the holes *M* and *M* in the projecting lugs shown in Fig. 78 are placed in the same relation to the sides of the friction sleeve. The collars are marked to avoid mistakes, and corresponding marks on the jig provided so as to assure proper location. The friction sleeve is clamped in place by a strap which in this case does not form an integral part of the jig. This arrangement, however, is cheaper than it would have been to carry up two small projections on two sides of the jig, and employ a swinging leaf and an eye-bolt, or some

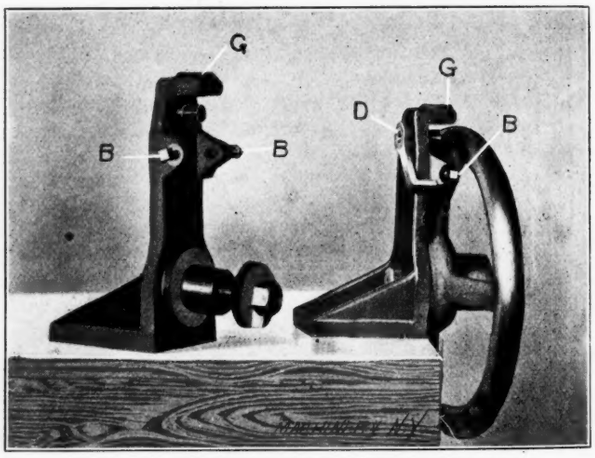


Fig. 81. Drill Jig for Holes in Rim of Hand-wheel.

arrangement of this kind. Besides, the strap is rather large, and could not easily get lost. The jig necessarily has a number of loose parts, on account of being designed to accomodate different details of the friction clutch.

The friction disks *C*, in Fig. 78, when drilled, fit directly over the projecting finished part *H* of the jig, and are located on this projection by a square key. The work is brought up against the bottom of the jig and held in this position by the same strap as is used in Fig. 80 for holding the friction sleeve. The bushings of different sizes, shown in Fig. 80, are used for drilling the different sized holes in the different parts.

In all the various types of drill jigs described above, the thrust of the cutting tools are taken by the clamping ar-

rangement. In many cases, however, no actual clamping arrangements are used, but the work itself takes the thrust of the cutting tools, and one depends entirely upon the locating means to hold the piece or jig in the right position when performing the drilling operation. It may be well to add that large bushings ought to be marked with the size and kind of cutting tool for which they are intended; and the corresponding place in the jig body where they are to be used should be marked so that the right bushing can easily be placed in the right position.

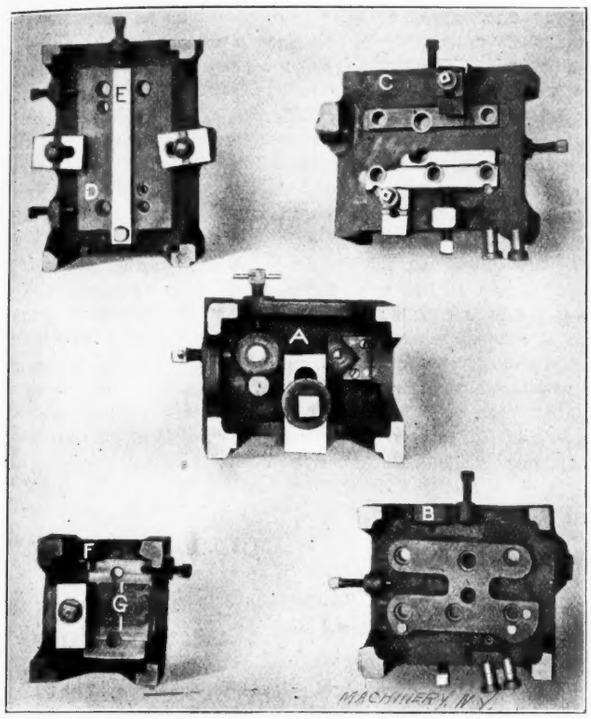


Fig. 82. Miscellaneous Examples of Open Drill Jigs.

A few more examples of open drill jig designs of various types may prove instructive. In Fig 81 are shown two views of a jig for drilling two holes through the rim of a hand-wheel. To the left is shown the jig itself and to the right the jig with the hand-wheel mounted in place, ready for drilling. As shown, the hand-wheel is located on a stud through its bore, and clamped to the jig by passing a bolt through the stud, this bolt being provided with a split washer on the end. The split washer permits the easy removal of the hand-wheel when drilled, and the putting in place of another hand-wheel without loss of time. The hand-wheel is located by two set-screws *B* passing through two lugs projecting on each side of a spoke in the hand-wheel, the set-screws *B* holding the hand-wheel in position while being drilled by clamping against the sides of the spoke. The jig is fastened on the edge of the drill press table, in a manner similar to that indicated in the half-tone, so that the table does not interfere with the wheel. The vertical hole, with the drill guided by bushing *G*, is now drilled in all the hand-wheels, this hole being drilled into a lug in the spoke held by the two set-screws *B*. When this hole is drilled, the jig is moved over to a horizontal drilling machine, and the hole *D* is drilled in all the hand-wheels, clamping the jig to the table of the machine in a similar manner as on the drill press.

In Fig. 82, at *A*, an open drill jig of a type similar to those shown in Figs. 73 and 75, is shown. This jig, however, is provided with a V-block locating arrangement. An objectionable feature of this jig is that the one clamping strap is placed in the center of the piece to be drilled. Should this piece be slender, it may cause it to bend, as there is no bearing surface under the work at the place where the clamp is located, for taking the thrust of the clamping pressure.

At *B* and *C* in the same engraving are shown the front and back view of a drill jig, where the front side *B* is used for drilling a small piece located and held in the jig as usual; and the back side *C*, which is not provided with feet, is located and applied directly on the work itself in the place where the loose piece is to be fastened, the work in this case being so large that it supports the jig, instead of the jig supporting the work.

At *D* in the same engraving is shown a jig for locating work by means of a tongue *E*. This tongue fits into a corresponding slot in the work. This means for locating the work was referred to more completely in connection with locating devices. Finally, at *F*, is shown a jig where the work is located by a slot *G* in the jig body, into which a corresponding tongue in the work fits.

It has not been possible to show actual designs of more than a few types of open drill jigs, the design, of course, varying according to the work to be drilled. The examples shown, however, will indicate the most common constructions, and exhibit plainly the application of the general principles laid down for jig design in the previous installments of this series.

* * *

AUTOMATIC PROFILING MACHINE.

The accompanying half-tones illustrate a profiling machine of the horizontal type, which, while on the one hand being provided with a guiding pin resting on a former, as in ordinary profiling machines, also combines this guiding arrangement with the feature of having a positive rotary as well as linear movement of the work-carrying slide. This permits work of any shape being profiled, either circular or nearly circular, or such having a long, narrow oblong outline. In the latter case, if the machine were not provided with a combination movement of the kind referred to, it would require that the cutter head would rise and fall through a considerable distance. With this combination movement, however, supplementing the movement caused by the guide pin on the former, any shape can be profiled with but a very slight movement of the cutter head.

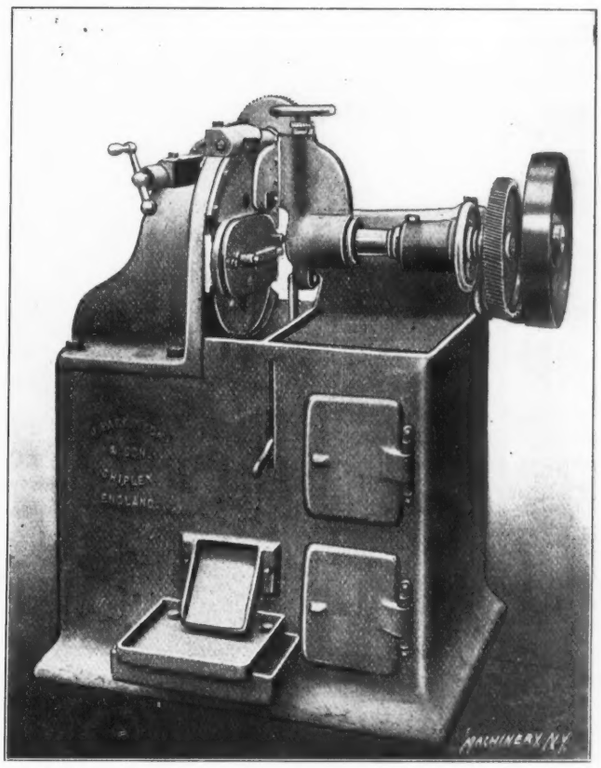


Fig. 1. Automatic Profiling Machine built by Messrs. J. Parkinson & Son, Shipley, England.

The machine is built by Messrs. J. Parkinson & Son, Shipley, England, and was originally designed for milling the outline of bicycle cranks and the connecting-rods for small combustion engines. In the accompanying half-tone, Fig. 4, a bicycle crank is shown fastened to the work-carrying slide. The main features of the machine may be stated in a summary manner as follows: The rate of feed is the same on both the rotary and linear movements, so that the rate of output is

governed only by the strength of the cutter and the quality of finish required. It profiles automatically right around the article to be machined either once or as many times as desired; if required, the machine can be set to trip automatically on the conclusion of a portion of a revolution. The alteration for different lengths of linear motion in proportion to rotary motion is made simply by replacing a single pin, while the

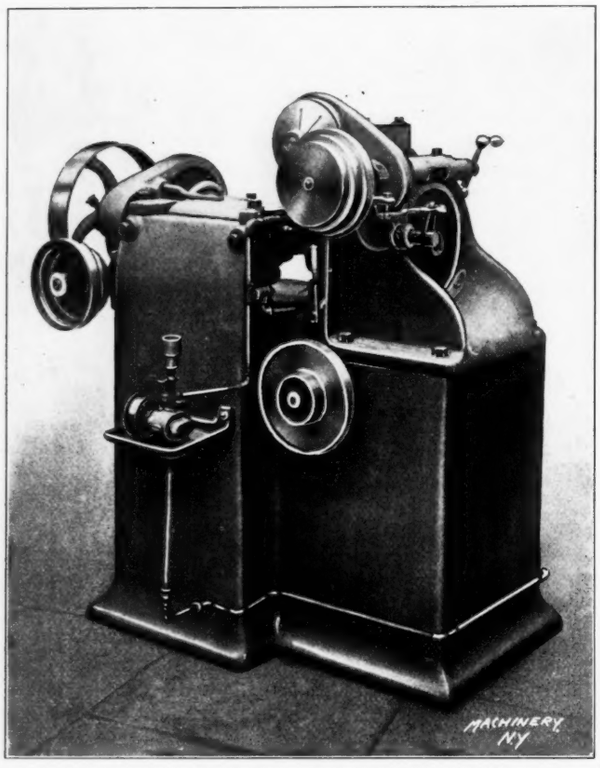


Fig. 2. Rear View of the Automatic Profiling Machine.

turning of a tumbler lever converts the action of the machine to a purely rotary one. There is but one trip movement for the double change from rotary to linear motion and back from linear to rotary motion.

The general appearance of the machine is shown in Figs. 1 and 2, the former showing a front view and the latter a back view of the machine. It is driven by a single belt from the counter-shaft, both the cutter spindle and the work-holding head receiving its motion from this pulley. The spindle is

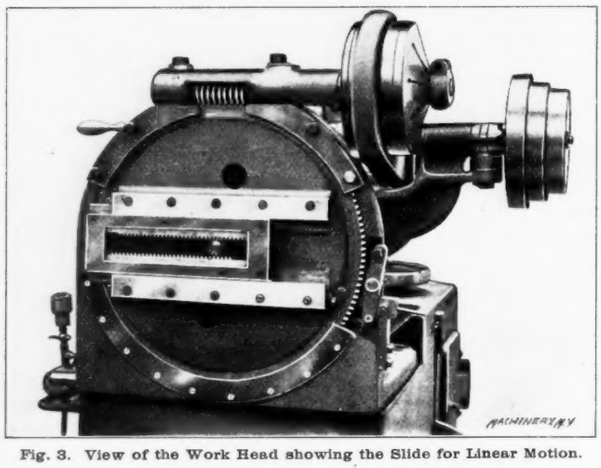


Fig. 3. View of the Work Head showing the Slide for Linear Motion.

carried by a swiveling bracket as shown, and driven by a pair of spiral gears. The cutter can be lifted clear of the work by means of a hand lever indicated at the front of the machine. The former-pin or runner is carried by the same bracket as the cutter spindle, and the latter's path is made to conform to the path of the former-pin by means of a pantograph link thereby transferring the shape of the former geometrically to the work to be machined.

The work head is driven from a cone pulley on the back of the machine, which can be connected to or disconnected from the driving mechanism of the head by a clutch. There are two worm-wheels in the head, one at the front and one at the back. These two worm-wheels are driven at exactly the same speed, but the front worm-wheel is only driven intermittently. The front worm-wheel carries the guides in which works the slide for the linear motion, as shown in the half-tones, Figs. 3 and 4. In this slide are fixed two compound racks placed face to face. The racks are made compound in order to be able to compensate for wear and eliminate back-lash. Between the two racks a pinion is placed which is driven directly through a shaft from the back worm-wheel. The pinion is so placed that when in mesh with one rack it just clears the other, as plainly shown in Fig. 3. This arrangement, of course, throws the axis of the two worm-wheels eccentric with each other to an extent equal to the addendum of the rack teeth. In order to understand the action of the machine it should first be kept in mind that the back worm-wheel and therefore the pinion meshing with the rack, are always revolving at a constant speed.

Now, suppose that the front worm-wheel is stationary. The small pinion which rotates with the back worm-wheel will drive the rack with which it is in mesh. When the slide thus driven reaches the desired position in its travel, the screw at the end of the slide comes in contact with a lever by means of which the front worm-wheel is engaged and commences to rotate. This is done either by allowing a friction gear to start driving the worm or by allowing a positive clutch to come into action. Both worm-wheels are now revolving in

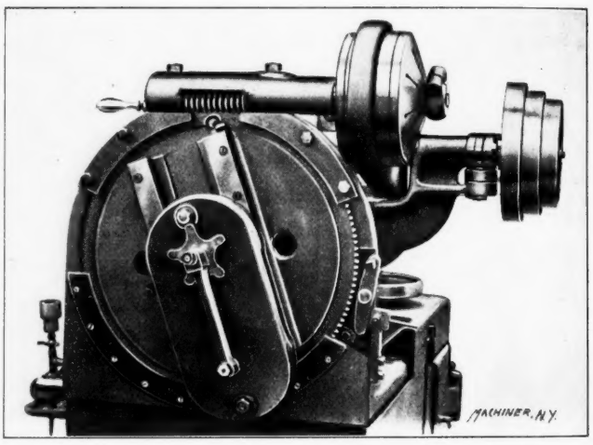


Fig. 4. Bicycle Crank fastened to the Work-carrying Slide.

unison, and therefore the linear movement of the racks and the slide ceases; but inasmuch as the axis of the front worm-wheel is eccentric with that of the pinion, the rack that was in mesh with the pinion is gradually withdrawn, and the other rack is brought in mesh until at the end of half a revolution the pinion is in full mesh with the second rack and the front worm-wheel is brought to a stand-still automatically on account of releasing the pressure on the lever by the screw in the end of the slide.

Immediately when the front worm-wheel ceases to rotate, the slide is once more driven in a linear direction by the pinion, but the motion of the slide is in the opposite direction in relation to its guides on the worm-wheel. This cycle can be repeated any number of times. When a different length of linear motion is required a longer or shorter screw is placed in the end of the slide to act on the stop. When a purely rotary movement is required the stop is permanently removed from the front worm-wheel.

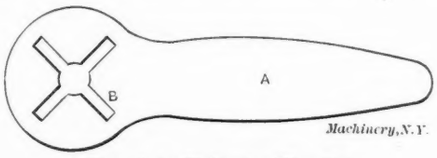
* * *

A creosoted wood conduit was recently removed from Sixth Avenue, New York City, and was found to be in excellent condition after 21 years' use. This conduit, which is the product of the Wyckoff Creosoting Co., was placed in 1887, and had to be removed this year in the excavation for the Hudson River Tunnels. It is in as good shape as when laid, and is being stored for possible future use.

ITEMS OF MECHANICAL INTEREST.

A WRENCH FOR WING NUTS.

Most of us have had to tighten up wing nuts by hand, which, of course, is what they are intended for, but sometimes it is convenient to be able to apply some tool for the tightening up of these nuts. For such a purpose the simple little tool illustrated in the accompanying line engraving,



A Wrench for Tightening Wing Nuts.

taken from the *Horseless Age*, will be found convenient. The wrench is made of flat stock about 3/16 inch thick. The handle *A* is made in various sizes, according to the size of the wing nut, five times the distance across the wings of the nut being the usual practice. Two slots *B* are cut at right angles to each other in the circular part of the wrench, as shown. At their intersection the central opening is enlarged, so as to permit the screw on which the wing nut turns to enter.

INTERESTING TYPE OF EMERY WHEEL.

The accompanying illustration, reproduced from *The Mechanical Engineer*, July 17, 1908, shows a type of emery wheel which is claimed to be a decided improvement on the ordinary type of cup wheel made in a continuous ring. The advantages depend, it is claimed, on the fact that the spaces between the teeth, or blocks, of the emery wheel permit the air to freely play around them, thereby keeping them cool, and giving the dust created by the grinding an opportunity to more easily escape. The teeth are, in reality, loose sections

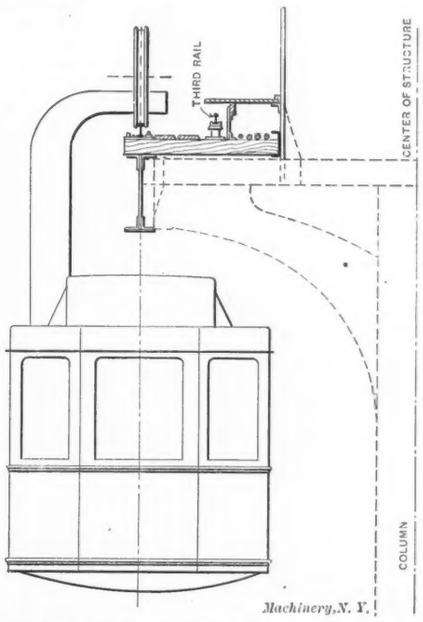
New Type of Emery Wheel which, it is claimed, is Superior to the Ordinary Cup Wheel.

or segments, held in a special chuck. Each segment is secured thoroughly by a set-screw which is tapped through the enclosing casing, the screws acting on special clamping plates, forcing the segments down into the opening provided for them, thereby wedging them in place. This type of emery wheel has been patented by Messrs. Luke & Spenser, Ltd., Broadheath, England.

It is difficult to say, off-hand, to what extent a wheel made up in this manner will prove practical. It seems that there are some very strong points in its favor. While it may seem at first sight as if a wheel of this type would be more expensive to make than the ordinary cup wheel, that factor is likely to be offset by the fact that the "teeth" of the wheel shown are very simple parts to make, and the great loss incidental to emery-wheel manufacture due to breakage and cracking during the drying processes are largely eliminated. The same advantages in this respect as are manifest in inserted teeth milling cutters would be gained in this "inserted teeth" emery wheel.

THE BERLIN SUSPENDED RAILWAY.

The transportation problem within the city limits has lately commanded a great deal of attention in Berlin, Germany, on account of the rapid extension of the city. The city is already provided with subway and elevated railroads, running from east to west, but has not adequate rapid transit facilities from north to south. It has been concluded that the expenditure incident to a subway would not be warranted by the traffic, and it was necessary to decide upon some kind of an elevated structure. It was considered, however, that the ordinary elevated railroad structure, as found in American cities, shut out too much light from the street below, and the type of suspended railroad, as indicated by the accompanying line-engraving, is projected. The dotted lines indicate one-half of the steel structure, which consists simply of a single column, or pedestal, in the center of the street, being provided at the top with the necessary structure for carrying one rail on each side. As shown in the illustration, but one rail is necessary



End Elevation of Car resting upon the Single Rail upon which it Travels.

for the traffic in each direction, the car being suspended below the rail by substantial hangers, and the center of gravity of the car being exactly below the center of the rail. In curves, the car will swing inward or outward, according to the direction of curvature, and the unpleasant sensation to passengers commonly experienced on curves is avoided. The system permits not only much sharper curves than are permissible in ordinary railroad construction to be used, but there is less need of slower speed around the curves, the average speed being twenty miles an hour. In order to make the objection to the elevated structure as slight as possible, an ornamental design has been adopted, and the rails are located 34 feet above the level of the street.

* * *

It is announced in *Figaro* that work has begun on the construction of a central station of wireless telegraphy in Paris to be used in connection with the Eiffel tower. The station itself, which will be provided with receiving and transmitting apparatus of exceptional power, is placed under ground, and is joined by wires with the extreme top of the tower. It is claimed that there are good reasons for believing that with a similar station erected in New York, direct communication between New York and Paris would be possible. Lee DeForest has announced that such a station will be established in the tower of the Metropolitan Life building and that he hopes to establish telephonic as well as telegraphic communication across the Atlantic.

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We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

OCTOBER, 1908.

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MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition—$1.00 a year, comprising more than 430 reading pages and 36 Shop Operation Sheets, containing step-by-step illustrated directions for performing 36 different shop operations. The Engineering Edition—$2.00 a year, coated paper $2.50—contains all the matter in the Shop Edition, including Shop Operation Sheets, and about 250 pages a year of additional matter, which includes a review of mechanical literature, and forty-eight 6 x 9 data sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. RAILWAY MACHINERY, $2.00 a year, is a special edition, including a variety of matter for railway shop work—same size as Engineering and same number of data sheets.

COOPERATIVE INDUSTRIAL EDUCATION.

The cooperative educational plan instituted in Cincinnati by which students in the Cincinnati University are enabled to obtain practical knowledge of machine construction and mechanical work in the Cincinnati shops has attracted much favorable attention. Analogous to this plan is a new movement in industrial education just put into effect in Fitchburg, Mass. This, we believe, is one of the most practical plans of industrial education ever formulated, and an account of it will be found on another page of this issue. Briefly, the plan is to educate young men in the machine-shop art and in the high school, simultaneously. The students taking the cooperative course are arranged in pairs, one student spending one week in the high school while his partner works in the shop. The next week the position is reversed, and so on. The lads taken into this course must have previously spent one year in high school, and they are required to take a three-year apprenticeship course in mechanical work, so that a four-year high school course and the machine shop apprenticeship are finished the same year.

The general result of such an educational system should be highly satisfactory, both as regards the manufacturers and the boys. It is common experience that the most active mental state exists with a moderate degree of physical exercise, so that students attending high school one week and working in the shop the next should be in the fittest condition for acquiring the elements of a trade and appreciating the value of an academic education. The condition of such a boy upon graduation is advantageous. He is not necessarily committed to being a machinist all his life, but is as free to enter any other vocation as are his mates who have only the advantage of an academic education. The fact that he is the master of a trade will be a very valuable help to him, however, even if his ambition lies in the direction of higher education and a profession. A poor boy can earn his way in a more dignified and agreeable manner than the majority of poor students, who generally have to resort to all sorts of menial occupations to get along. If the cooperative student chooses to become a machinist, his general education and special mechanical instruction should fit him to fill, ultimately, the highest positions in the manufacturing world.

UNLAWFUL USES OF PATENTED MACHINES.

An interesting point in patent law was recently passed on by the Circuit Court of the United States in the Eastern District of Pennsylvania, in a suit to enjoin the further use of patented machines that had been sold for scrap. The court enjoined the use by a manufacturing concern of two crank-shaft lathes sold by the complainant company to a junk man. The machines, which were nearly complete in all essential details, were bought, repaired, and put in use by a competitor. The judge of the circuit court in granting the injunction restraining the use of the machines by the defendant company, held that while the purchaser of a patented article from one who is authorized to sell, becomes possessor of an absolute property right in it (Keeler *vs.* Standard Folding Bed Co., 157 U. S. 689) which he is capable of also transmitting to others, in this case the right of use did not follow the sale, inasmuch as the complainant company sold the machine as scrap. "A sale as scrap was a sale not to use, but to destroy; and cannot be wrested into a sale of the patented machines because the different parts could be picked up and put together again. (Wortendyke *vs.* White, 2 Ban. & Ard. 25; Cotton Tie Co. *vs.* Simmons, 106 U. S. 89)." It was also alleged by the complainant company that the machines were fraudulently disposed of by a foreman who now is an officer of the defendant company.

The principal enunciated in the judge's decision is important to users of second-hand patented machinery and apparatus of whatever description, especially if the route by which they came into the user's factory is obscure. It seems doubtful that the decision is entirely sound, as such a ruling might easily be made to impose unwarranted hardship on innocent purchasers. If there were no other remedy for the unlawful use of discarded patented machines, there would be good reason for the injunction, but any concern about to dispose of machinery for scrap can separate the parts and break them up so that reconstruction is impossible. The sale of a machine in workable or nearly workable condition, and without destroying the possibility of use, appears to us to carry with it an implied right to make further use thereof for its original purpose. The decision referred to, if sustained, might have unexpected results. For example, it might cause serious interference with the sale of second-hand patented steam boilers, if the manufacturers were disposed to place an embargo on their further use. Steam boilers are commonly disposed of by power companies and others to junk dealers, when they have outlived their usefulness for high-pressure work. The junk men sometimes sell them to persons who want low-pressure boilers for steam heating and other work not so severe as power generation, and it seems unreasonable that such a boiler, sold without breaking up, should not be used by the purchaser for the designed purpose. The fact that it was sold to the junk dealer ostensibly as scrap should not entail the destruction of the boiler unless a specific agreement was made to that effect. The second-hand value of a boiler having a possible further use is greater, of course, than if it were sold to be converted into scrap; but if the fact that the construction happens to include some patented feature can be used to prevent further use beyond the original buyer, an injustice would undoubtedly be worked on unsuspecting purchasers.

The case in point is considerably complicated by the allegation that an employe of the complainant company disposed of the machines fraudulently, having sold them among other scrap when the officials of the company had no intention of disposing of the machines, which it is alleged had simply been removed from the machine-shop while awaiting repairs and further use. It is not clear from the text of the decision whether the judge took particular cognizance of this fact in granting the injunction, or whether he based his opinion entirely on the fact that the machines were sold for scrap and that such sale did not carry with it the right of use for their original purpose. A fraudulent sale, of course, would not carry with it the right of use of a patented article, or any other right or title; but as the complainant company was unable to establish a fraudulent sale, it appears that the court's decision was based simply on the assumption that a sale for scrap is not a sale for use, and that the user may be enjoined from such use.

PRESERVING RECORDS.

Some time ago we published an editorial on "Keeping Things Seven Years," in which was questioned the advisability of storing away for future use odds and ends left around the shop. There are two departments in the shop, however, where almost everything pertaining to the work should be kept, even when it apparently has passed its time of usefulness. These departments are the general office and the drafting-room. Little need be said about preserving the records in the office. Those pertaining to the mercantile end of the business are, of course, carefully preserved; but in the drafting-room, the practice is not always well defined. Regular drawings, it is true, are filed away, but a considerable part of the work in the average drafting-room consists in making small sketches, often in a hurry, for some special work in the shop. Often these are made simply in pencil and are not traced or blue-printed, the sketch itself being sent out in the shop, so that no record is left in the drafting-room. Sometimes the sketch is lost in the shop, the work perhaps being half completed, and under such circumstances it is much more difficult to make another drawing that will conform to the work partly done, than it was to make the original lay-out. The saving of time incident to this method of sending sketches and drawings into the shop is usually so small that it does not seem worth while to invite all the trouble that often comes from it; and for this reason a record of everything in the shape of a drawing, sketch, order or specification which goes into the shop from the drafting-room, should always be kept in some form so as to preserve a permanent record. While it may require a few more hours' work, at times, to systematically adhere to this policy, in the long run it will save a great deal of trouble and expense. Of course, we know that in hundreds of drafting-rooms such a system is already in force, but we also know that in a great many the haphazard methods referred to are practiced.

The faculty of memory, while one of the most wonderful qualities of the human mind, is at the same time one of the most uncertain, and it often fails at the very time when its accurate working is of the greatest importance. For this reason *anything worth remembering is worth placing on record.* The drafting-room may seem to be overcrowded with the card indexes, files or cabinets necessary to a scrupulous adherence to this principle; but there will be less time wasted searching for things mislaid or destroyed. Time is money.

* * *

GUESSWORK IN MACHINE TOOL DESIGN.

Machine tool designers and men engaged primarily in the construction of small machinery of that type, who have not had experience along other lines of mechanical achievement, are often prone to look upon calculations and formulas for the strength of materials and similar means for exact analyses as rather unnecessary, and of interest, not to practical men, but merely to the student. Engaged, as they are, in work where no great damage is done if a part proves too weak and breaks, as it can easily be repaired and replaced, the new part being sometimes made a little stronger or of the same dimensions and liable to break again under too heavy stresses, they do not seem to fully realize that in some kinds of engineering work such failures cannot be risked, for they may result in loss of life and property of appalling magnitude.

If a belt from the counter-shaft to the driving pulley should happen to be too narrow and should break under the stress of a heavy cut, the mishap may be inconvenient and cause a little trouble, but as a rule no great damage is done; while if the mast on a crane intended to lift 10,000 pounds buckles and fails when a large casting of this weight is suspended from the hook, with several men on the foundry floor near by, the danger and the loss is too serious to be lightly considered. A lever on an automatic machine subject to constant vibrations may finally break; the breakage may cause temporary difficulty, but no great harm is done, and the damage is merely a small pecuniary one; but if one of the trusses on a railway bridge is improperly calculated and designed and gives way under the weight of an express train, the damage cannot be expressed in dollars and cents.

Thus there is some reason why men engaged in the design of small machinery should leave so much to guesswork, depending largely on "snap" judgment, a condition which is not permissible in the design of machinery subjected to stresses where failure means considerable damage. This element of chance and guesswork plays an important part in the design of machine tools, too important, in fact, for the continued prestige of designers. There are many things that could be calculated to a certainty, even on machine tools, which are proportioned merely on the designer's judgment, and the outcome is left to chance in many cases where it is unnecessary. The judgment of a machine tool designer, of course, is one of his greatest assets, but he should not despise the manner in which the designer of other classes of machinery works, where it is necessary to determine exactly the dimensions and the conditions of the design. He should learn rather to adapt himself to methods of exact analysis when and where the conditions demand it. The combination of the qualities of instinctive machine design and design by mathematical analysis is most invaluable.

* * *

MACHINE TOOL BUILDING AND ECONOMICS.

The mechanical progress of the last twenty-five years has been marvelous. The new inventions which have been brought forth, and which are constantly being perfected, have placed the machine industry, and particularly the machine tool manufacture, on an extremely high plane mechanically. Our highly developed and firmly established shop systems, proper management, and general all-around intelligence, have made economical production in the shops possible in a degree which was not expected even a few years ago. But, in spite of all this, we have temporary depressions in the machinery trade, for which there seems to be no reasonable cause. The fact is, however, that our business men, as well as our mechanics, while they have developed the science of individual economics of the shop to a high perfection, invented and improved labor-saving machinery, and, in general, placed the business, industrially, on the firmest ground, have not given due attention to the outside influences, those influences which do not depend upon the individual economics of each shop, but upon the economical principles applied to the nation as a whole.

It is not the office of MACHINERY to teach political economy, but inasmuch as the machine tool industry, and all other industries in the country, for that matter, can only secure for themselves a small portion of the prosperity to which they are actually entitled, if they are hampered by adverse conditions of economics applied to the nation, we consider it proper to ask our readers to give more attention to a subject that is fully as important to the development of the trade to which they have devoted themselves, as the economical and commercial development of the individual shops.

There is but one legitimate cause for hard times, and that is the failure of crops. When depressions and hard times occur without being provoked by this cause, the reason is an artificial one, which can be removed if we only give due attention to the economic problems that cause it. Wonderful as our industrial progress during the past century has been, it will prove of little value in the end, if the manufacturer as well as the mechanic do not find it easier to secure, on the one hand, a fair profit, or, on the other, continuous employment at fair wages. It is time that the men employed in industries which depend so largely on the solution of some of our economic problems, should no longer ignore giving attention to so important a subject.

Inventions alone are not the only thing necessary to the prosperity of the machine industry. It is equally important that each man, whether he be a manufacturer or an employe, receives a fair equivalent for his exertions, and that he should not need to fear depressions caused simply by artificial economic conditions. If the business men and the mechanics of this country would give more attention to economic conditions and problems of this character, they could better safeguard themselves against such difficulties.

ENGINEERING REVIEW.

CURRENT MECHANICAL EVENTS—LEADING ARTICLES OF THE TECHNICAL PRESS.

As the result of the agitation which has been in progress for many years, the technical schools and universities of Prussia have, by a recent decree, been opened to women. Such privileges had already been granted in some of the smaller states.

The experiments on the elevated railway lines in Chicago to eliminate noise by the use of a gravel roadbed on the structure, has recently been abandoned, as the gravel not only failed to reduce the noise, but held water, with injurious effects to the structure.

The best preventative for spontaneous ignition of coal, says *Compressed Air*, is a small cylinder containing compressed carbon dioxide, fitted with a fuse plug melting at 200 degrees F. A cylinder one foot long and 3 inches in diameter is sufficient to take care of 8 tons of coal.

Two motor shows are to be held in France the latter part of this year, one being for private and the other for commercial vehicles. Both exhibits will take place in the Grand Palais. The show for pleasure cars will be open from November 28 to December 13, and that for commercial motors from December 22 to 29.

The importance of cement in engineering work is indicated by a contract recently made by the United States Government with the Atlas Portland Cement Co. for the Panama Canal. The contract is for 4,500,000 barrels of Portland cement at a cost of $5,500,000. This, it is said, is the largest single contract ever given out in the Portland cement business. The contract calls for a minimum shipment of 2,000 barrels a day and a maximum of 10,000. The present productive capacity of the company is 40,000 barrels per day.

The Pennsylvania Railroad forestry department has just completed its forestry planting for this year. It is stated by *Railroad Men* that 625,000 trees were planted. This makes a total of 2,425,000 trees set out by the Pennsylvania Railroad up to the present time. The object is to create an adequate supply of timber for ties required in years to come. The Pennsylvania Railroad evidently is taking active steps in regard to the preservation of natural resources. The true way of preserving our forests is not necessarily not to use them, but to replant them.

Cotton gins, printing, spinning, weaving machines, and scientific instruments are being exported from Japan to China, India and the United States. The exports of machinery for 1907 is reported by Consul General H. B. Miller, of Yokohama, to have increased 61 per cent, and there is an increase over the average for five years of 250 per cent. Thus far the exported machines have been mostly copies of foreign models, but the makers of violins at Nagoya have invented labor-saving appliances, and the tea-firing machinery used in Japan is chiefly of native invention.

The twelve new torpedo boats under construction for the German Navy are to be driven by steam turbines. According to *Engineering*, it is planned to try four different types of turbines. The three boats which the Vulcan yards near Stettin are constructing are to be equipped with turbines of the Curtis type. The four boats which the Schichau yards of Elbing and Danzig have undertaken to build, will have Melms and Pfenninger turbines. Of the five torpedo boats under construction at the Germania yards at Kiel, four are equipped with Parsons, and one with Zoelly turbines.

A union railway station is now in the course of construction at Leipzig, Germany, which will be one of the largest in the world. The five terminal stations which are in Leipzig at the present time, will all be removed upon the completion of the new terminal. This latter is to have 26 parallel tracks which will accommodate the trains of 13 different lines, and between each pair of tracks is to be a walk 40 feet wide, so that the total width of the train shed will be nearly 1,000 feet. The main facade of the building will be 1,115 feet wide, or over 350 feet greater than the facade of the new Union Terminal at Washington, D. C., which is at present the largest in this country.

The Cunard steamer *Lusitania* broke all records on her western trip ending August 21. She crossed the Atlantic in 4 days and 15 hours, the total distance traversed being 2,780 knots. The best day's run was 650 knots. The best hourly speed was 25.66 knots and the average for the trip was 25.05 knots. This trip demonstrates the ability of the vessel to make the average speed required by the terms of the subvention allowed by the British Government, it being required by the terms that the vessel make one trip at the rate of 25 knots.

While the discussion of the recent disaster of the collapse of the Quebec bridge is still occupying the engineering profession, reports of a similar accident come from Germany. On July 9 a bridge under construction over the Rhine, at Cologne, fell, and at least fourteen of the men engaged on the bridge work lost their lives, and nine men were taken from the water severely injured. The traveler used in erecting the central span collapsed, and carried with it all of the steel work. While not as disastrous an occurrence in regard to the loss of life as the Quebec bridge collapse, it was perhaps, merely by chance that no more men were, at the time, engaged on the work on the bridge, and the occurrence of two accidents of so similar a character, one in America and one in Europe, indicates that the engineer has still a great deal to learn and that, particularly in structural work, too great pains can never be taken by those in charge of design or erection.

In an editorial in *Engineering News* attention is called to the practice of sending catalogues to prospective customers without price lists, even though a price list may have been specifically requested. The idea is that the customer should state in detail the particular machines he is interested in, and prices will be furnished him for these only. Sometimes, however, the lack of definite information given to the customer is the cause of loss of big contracts. In the present case, a firm in Chile had requested manufacturers of mining and smelting machinery to furnish catalogues and prices. Many American manufacturers furnished catalogues, but did not attach price lists, whereas all the European manufacturers gave definite prices and terms. As correspondence between Chile and the United States requires some six weeks or two months in each direction, and delay was not permissible in this case, the result was that an order for $75,000 worth of machinery was cabled to Europe and lost by the American trade.

The original supply of coal in the state of Pennsylvania is estimated by Mr. M. R. Campbell, of the United States Geological Survey, to amount to 21,000,000,000 short tons in the anthracite fields, and 112,574,000,000 short tons in the bituminous fields. It is interesting to note the statement that by the methods of mining anthracite coal in former years, for every ton of coal mined and marketed one and one-half ton were either wasted or left in the ground as pillars for the protection of the workers, so that the actual yield was only about 40 per cent. This percentage of waste has been greatly reduced in later years. Of the original available supply, as mentioned above, it is estimated that there is 17,000,000,000 tons of anthracite coal left, of which one ton can be mined for each ton lost. This would indicate that the Pennsylvania fields can still yield 100 times the quantity

of anthracite produced in 1907. The supply of bituminous coal at the rate of production in 1907 would not be exhaused for nearly 500 years.

Economy in the use of material is the first law in manufacturing, but there are certain economies that may be obvious when once known, but which have developed slowly and have to be seen to be appreciated. In the manufacture of twist drills it formerly was the practice to cut bar stock for drills into short lengths about six feet long. It finally was realized that "every bar has two ends," and that the proportion of waste with the six-foot bars was more than with the 12- to 14-foot bars. The Standard Tool Co., Cleveland, O., no longer cuts its stock into lengths as short as 12 or 14 feet even, but stores them in mill lengths of 24 to 28 feet, thus reducing the waste due to croppage to a minimum. The stock is stored on end in a concrete storage warehouse specially constructed for convenience in unloading from cars and supplying the needs of the factory. The stock is leaned against the side walls and a central rack. Each stock has its own stall, the sizes running from ¼ inch up. Of course, the small sizes come in shorter mill lengths, it not being feasible to handle or store these in lengths of 24 feet or more. The central rack in this storehouse has three arc lights overhead for illuminating the stock at night or during the dark days in winter. The storehouse is warmed by five hot-air discharge flues distributed in the warehouse so as to keep the steel at a comfortable temperature to handle, no matter what the outside weather may be.

AERONAUTIC RECORDS.

Leon Delagrange, president of the Aviation Club of France, established a new world's record with his aeroplane at Issy, near Paris, September 6. His machine remained in the air 29 minutes, 54 4/5 seconds, and circled the field 15 1/2 times, covering a distance of about 15 1/4 miles. On the following day Delagrange remained in the air 31 minutes, but was penalized three minutes because his machine touched the earth while making the first round of the field. On September 5 Wilbur Wright made a flight with his aeroplane at Le Mans, France, of 19 minutes 48 2/5 seconds and traveled between 14 1/3 and 15 miles. Following is a partial record of the progress of the heavier-than-air flying machines during the past year, taken from the *New York Times*:

Oct. 15, 1907—Henry Farman traveled 285 meters near Paris.

Jan. 13, 1908—Farman won the Deutsche Archdeacon Prize by sailing a kilometer in a circle near Paris.

March 20—Farman flew his aeroplane 1½ miles near Paris.

May 13—The Wrights flew 3 miles in 3 minutes near Paris.

May 18—Baldwin's aeroplane *White Wings* made a short flight near Hammondsport, and five days later traveled 183 yards and then upset.

May 27—Delagrange's aeroplane flew 6 miles before the King of Italy at Milan, and next day made a record flight of 10 miles.

June 29—Bieriot's monoplane won the Aero Club's medal by flying 100 yards.

July 4—Curtiss's aeroplane the *June Bug* flew one mile, and won the *Scientific American* Cup.

July 7—Farman won Armongaud's $2,000 prize by remaining twenty minutes and twenty seconds in the air.

Aug. 2.—Farman, at the Brighton Beach track, went 700 yards in forty seconds.

Sept. 2—Two Cornell instructors covered three miles in five minutes in an aeroplane of their own making.

Sept. 3—While Orville Wright at Washington covered two-thirds of a mile in one minute, his brother Wilbur, at Le Mans, France, covered six miles in ten minutes.

Sept. 5—At Le Mans, Wilbur Wright covered 15 miles in twenty minutes in his aeroplane.

Sept. 9—Orville Wright made two record-breaking flights near Washington with the machine under perfect control. The distance covered in the longest flight was about 40 miles, the time being 62 minutes and 15 seconds.

Sept. 11—Orville Wright again breaks his record by remaining in the air 70 minutes and 24 seconds.

SMOKELESS FUEL.

Mechanical Engineer, August 14, 1908.

Mr. Sherard Cowper-Coles of Grosvenor Mansions, 82 Victoria Street, Westminster, London, has recently patented the following process for the manufacture of smokeless fuel. About one-third part by weight of wet peat and two-thirds part by weight of bituminous coal in a finely divided state, are placed in a retort and heated to a temperature sufficiently high (about 850 deg. F.) to drive off those hydrocarbons that produce smoke, the generation of the steam from the peat assisting in this operation. It will be understood that the temperature is not raised materially higher than is necessary to drive off the hydrocarbons, as above stated. The heat is applied for about five hours. The bituminous coal binds the peat together to a coherent mass and forms a fuel of high calorific value, which is readily ignited in a grate in the ordinary way and burns economically and without smoke. In practice the retort may be provided with relief valves and arranged so as to maintain a pressure of 10 pounds per square inch. The retort may also be fitted with a plunger which is forced to one end when the contents are in a plastic state, and it may be heated in any convenient way, such as by heat externally applied or by burning some of the gases generated after partial purification. The watery extract, containing tar of complex constitution, pyroligneous acid, and other products derived from the carbonization of peat, in addition to the gases above referred to, is advantageously condensed and utilized for the production of a pitch of superior quality, and the usual condensible products obtained from the bituminous coal in the retort may be collected and used for any desired purpose. In some cases the contents, after the above described process has been completed, may, either while still hot or after they have cooled, be discharged into a solution of calcium chloride. By this means the smokeless fuel is rendered slightly deliquescent and always retains a certain quantity of moisture. The coal or the peat, or both, may also be moistened with a solution of calcium chloride before being placed in the retort.

THE MANUFACTURE OF SLAG-CONCRETE BRICKS.

Engineering, August 14, 1908.

The amount of slag produced per ton of iron from the blast-furnace, varies in amount from ½ ton to about 1½ ton, according to the ores used; and, with the enormous output of pig iron at the present time, it is not surprising that attempts are continually made to find some satisfactory means of turning this material to account. The manufacture of concrete bricks from blast-furnace slag has become a commercial process of some value. The material, containing as it does a large amount of lime and silica, is eminently suitable for such a purpose. The granulation of the slag is first effected by running it, while still in a molten condition, into water. After granulation, the slag is passed between squeezing-rollers for the purpose of removing the excess of water and crushing any large particles. For mixing with the slag, white unslaked lime has proved most satisfactory, ground to an 8,000 mesh. The lime should not contain more than ½ per cent magnesia. The slag and unslaked lime in proportions of 95 to 93 per cent slag to 5 to 7 per cent lime, are tipped into a large hopper and passed thence to a steam jacket mixing machine; the heat, together with the moisture in the slag, starting the reaction of the lime. It is then taken to the presses, in which the pressure is exerted on the 9 x 3-inch side, thus insuring uniform thickness of all bricks, and from these presses the bricks are taken to steaming chambers. The slag must be of uniform grey quality, or variations in the color of the bricks will result. The success of the bricks depends on the care and uniformity with which the various operations are carried out. Uniformity of mixture and of pressing are most important. The moisture carried by the slag, when mixed with the unslaked lime in the mixing hopper, should not be more than 8 to 10 per cent. The resulting bricks compare very favorably with red bricks, and are of a more uniform quality than cement bricks made of zinc slag and lime, or refuse clinker. They have a crushing strength of between 2,500 pounds and 3,000 pounds per square inch, and have withstood very severe

boiling and freezing tests. The bricks are satisfactory for building purposes, and masonry built with them has fire-resisting qualities as good as, if not superior to, that built of red brick. Coloring matter can be added, if necessary, when mixing the lime and slag. The cost-sheet suggests that there may be a considerable future before this process, for the prices compare favorably with other bricks of equal quality.

BRAZING CAST IRON AND OTHER METALS.

Frank N. Blake in the *Horseless Age*, August 26, 1908.

Brazing consists in uniting metal parts by flowing melted brass, technically termed spleter, between them. It is practically identical with soldering, except that spelter is substituted for solder, and that a much greater degree of heat is necessary. In the greater degree of heat required to melt spelter lies one of the advantages which brazed work possesses over that which is soldered, the finished work enduring more heat without breaking or weakening; but the chief advantage lies in its superior strength at all temperatures and its applicability to a large variety of uses. Cast iron is a common material which is prone to break, and which can now be brazed. The production of the necessary heat is an important part of the process of brazing, and constitutes the chief difficulty and almost the only source of expense. For small work, a plumber's hand gasoline torch can be used in what may be termed an amateur sort of way, but for common use a forge, gasoline brazer, or a jet of gas supplemented by a blast of air can be satisfactorily used. The latter constitutes the cleanest, most convenient, and effectual brazing fire.

A bed of coke or charcoal on a forge hearth is an excellent resting place for the work during the process of brazing. A backing of firebrick or of asbestos is of considerable assistance in confining and reflecting the heat, though, of course, these do not contribute to the heating process in the way that inflammable backings do. There is considerable opportunity for the display of judgment and discretion in the arrangement of the backing; aside from the saving of time and fuel there is, on large and difficult work, all the difference between success and failure in the way the heat is applied and utilized.

Before work is assembled for brazing it should be well cleaned by file, scraper, scratch brush or other means; rust and scale do not favor the ready flowing of the fused spelter, though it will sometimes take hold of even such unfavorable surfaces. Cast iron may be cleaned by first heating to a bright red, and, after cooling, brushing the fracture and adjacent parts with a scratch brush. After thoroughly cleaning the work and securing good bright surfaces, the parts must be fastened together in the exact position they are to occupy when the job is completed. Usually the pieces are secured by pinning, but sometimes screws, bolts, wire, clamps of various sorts, and even fire-clay can be used to hold the parts in place. Whenever practicable, the parts should be secured in such a manner that the job can be turned over during the process of brazing, without disturbing the relation of the parts to each other, thus affording a better chance to apply the flux and spelter.

Alcohol used in a common gasoline torch has been said to give a greater heat than gasoline, the reason given being that it requires less air, and consequently the flame is cooled less by it. As alcohol contains fewer heat units than gasoline, it would seem a less suitable fuel to use for this purpose, but perhaps the need of less air may explain the difference claimed for it.

A simple and good formula for cast iron brazing is as follows:

	Ounces.
Boric acid	16
Chlorate of potash, pulverized	4
Carbonate of iron	3

Mix and keep dry, as moisture or long exposure to air renders it less efficient. When used, mix with grain spelter. Heat the work to a nice brazing heat and apply flux and spelter with an iron rod, flattened and spoon shaped at the end.

Borax is much used for flux in brazing wrought iron and steel; it is not expensive, and one can be sure of getting a good article by buying of a reputable dealer. In any brazing, the work is first brought to a bright red heat, flux is applied, and then mixed flux and spelter. Sometimes considerable "coaxing" is required in order to make the melted metal flow into the joints; but with the flux applied first and allowed to find its way into the cracks and openings, the spelter will follow if carefully led and rubbed with the hot iron rod. After one side of the work has been brazed, it is turned over and the other side is treated in the same manner.

In preparing work for brazing, too close a fit may be made, for the melted brass will not find its way into the most minute recesses. One one-thousandth of an inch is about as small a space as spelter will readily flow into.

After brazing cast iron, it is a good plan to let it cool slowly, sudden chilling being regarded as injurious in some cases. Whatever process is employed it is a good rule to have the work bright and clean, and to use plenty of heat; these, together with good flux and spelter, constitute the essentials. Experience is always valuable, but that comes only with practice.

TESTING STEEL TAPES AT THE NATIONAL BUREAU OF STANDARDS.

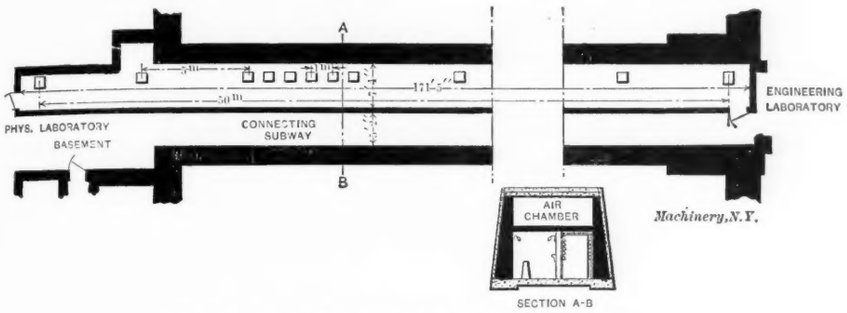
Herbert T. Wade in the *Engineering News*, August 13, 1908.

One of the most important functions of the National Bureau of Standards at Washington, D. C., is the testing and standardization of steel tapes of various lengths and forms, used in engineering work. These tests range from the minute and critical examination and study of the steel and invar tapes of the U. S. Coast and Geodetic Survey, employed in the accurate measurement of base-lines, to the inspection of the ordinary steel tapes of the surveyor and engineer. All of these tests are carried on in a specially designed laboratory, which is, without doubt, the best equipped for this kind of work of any testing bureau or physical laboratory in the world. In fact, it can be only compared with a somewhat similar room of less than half the length at the International Bureau of Weights and Measures at Sevrès, near Paris. Both of these laboratories are located underground, in order to secure a constancy of temperature, but the Washington testing room not only is better designed and equipped, but already its constants are known with a high degree of precision. The room is about 8 feet below the surface of the ground, 171 feet in length, and is about 8.2 feet in width and height. It is lined with white enamel brick, lighted by electricity, and contains steam and brine coils in addition to ventilation inlets and outlets, so that by the aid of thermostats the temperature can be controlled within narrow limits.

On one side against the wall is the United States Bench Standard of length, which consists of a steel bar mounted on rollers and supported horizontally on brackets. Opposite this standard is the comparator proper, used for the determination and standardization of steel and invar tapes for base-line measurement, and also for standardization of base bars of 5 meters in length from the national prototype meter standard. The floor of the room is of concrete, on which is laid a track for the carriage containing the ice trough in which the bar, used as a standard, is carried when measurements and comparisons are being made. There are eleven stone piers spaced 16.4 feet apart, and on these are mounted the micrometer-microscopes. Each pier is 14 × 14 inches in cross section and is set on a concrete base 16 inches square and 18 inches deep, the bases of the piers being separated from the floor by a space of 2 inches. This makes the piers and their foundations entirely independent of the floors or the structural walls of the building. At the north end of the tunnel the base of the terminal pier was built through a small vault to solid ground beneath, and is about 8 feet in height and 6 feet square. The piers at the ends carry not only the micrometers but also the marking bolts identifying the beginning and end of the standard distance. The tunnel thus arranged affords a comparator 50 meters (164 feet) in length, which is sufficient for the long tapes used in geodetic surveying. It might be said, in passing, that the development of the accurate use of tapes in the measurement of base-lines has been a striking feature of the work of the U. S. Coast and Geodetic Survey in recent years, and such precision has been attained in the use

of these tapes for measurements of base lines that they seem destined to supplant the more cumbersome base-bars.

Within a few years, invar tapes, made from an alloy of steel and nickel, discovered by M. Ch. Ed. Guillaume, of the International Bureau of Weights and Measures, have been thoroughly tested in the field after standardization in the laboratory, and the accuracy and convenience of their use has been clearly demonstrated. In using the comparator, the first step is to standardize a 5-meter steel or other bar in terms of the U. S. National Prototype Standard, which is a meter bar of platinum-iridium made at the International Bureau of Weights and Measures at Sevrès, and like the other similar national standards of length of the nations of the world, known most accurately in terms of the International Prototype Meter preserved at the Bureau. To transfer the meter to the five-meter bar, there are in the third interval of five meters between the piers, measuring from the south end of the tunnel, four similar and intermediate piers spaced a meter apart. These piers are of similar size and construction to the others, and on them the micrometer-microscopes



Horizontal and Vertical Sections of the Tape Testing Chamber.

can be placed so that the meter bar passed successively over the intervening five meter distances will give a standard distance of five meters with which the five-meter standard may be compared. The micrometer-microscopes are placed on iron brackets or arms which are attached firmly but in an adjustable manner to the tops of the stone piers, each of the latter having a hole cut through its top below the microscope arm so that light from an incandescent lamp hung back of the pier can be used for the illumination of the microscope and bar.

The micrometer-microscopes used in the standardization work of the Bureau, have been tested for many years by the Division of Weights and Measures of the Bureau of Standards and, previous to its establishment, by the Office of Standard Weights and Measures of the Coast Survey, so that the constants and operation of these instruments are known thoroughly, though the usual adjustment is for one division on the head of the micrcmeter to correspond to one micron on the bar. The standard meter is placed in shaved ice in a trough mounted on two trucks. This trough can be raised or lowered by simple and exact adjustments, and, in fact, the bar in the trough may be adjusted under the microscopes to a micron, or one-thousandth of a millimeter. The standard meter is placed under one of the microscopes at the beginning or end of the five-meter interval, and the cross hairs are set with great precision on the fiducial line marking the limit of the standard distance. Then the second microscope and its cross hairs are set on the line at the opposite end of the bar with similar accuracy. The bar on the supporting carriage is then moved along between the second and third piers and similar adjustments are made. In this way the standard length of five meters is established, and the value of the five-meter bar which then can take the place of the standard meter in the ice trough, is obtained. The value of the meter at the temperature of melting ice, 0 degree Centigrade, is accurately known, and this temperature figures as a standard in all metric determinations. With a five-meter standard accurately determined, it is possible to measure successively the ten intervals of the 50-meter base of the tunnel, the process being precisely similar to that followed in getting the value of the five-meter bar.

Not only must the temperature of the bars in the ice trough be known and regulated, but the temperature of the tunnel itself and of the tapes under test. For this purpose there are carried on the walls of the room 14 lines of pipe, the upper twelve of which are used for circulating brine cooled to a temperature of —10 degrees Centigrade and enabling the temperature of the room to be reduced to 0 degree Centigrade with facility. The two lower lines of pipe contain steam when desired, so that not only can the coefficients of expansion of the tapes be measured, but the temperatures of ordinary field work duplicated. This, of course, does not obviate the necessity of taking exact thermometer readings at each observation and determination, and these are made as usual with carefully calibrated thermometers.

The microscopes at the ends of the 50-meter comparator, to which reference has been made, are referred to the bronze bolts in the pier foundation to insure their greater stability. Having the distance between the two terminal microscopes accurately determined with the ice bar apparatus, it is only necessary to substitute the steel or invar tapes and to apply the standard tension with spring balances which previously have been calibrated with correct weights in another laboratory of the Bureau. The tapes can be supported at such intervals as would be employed in field work, and, by the temperature regulating apparatus already described, the temperature of the vault can be varied and the coefficients of expansion can be determined with great precision.

In making the standard tests, measurements are made with the ice bar apparatus in the morning and then again at night, and the mean of the two measurements is the standard distance for the day. The tapes ordinarily are measured after they have remained all night in the laboratory comparator room and have assumed its temperature. In recent tests of invar tapes the coefficient of expansion of tapes of 50 meters in length was determined with precision to a micron, and was found to range from 0.000000374 to 0.00000044 for 1 degree Centigrade. Thus invar has a coefficient of expansion of about 1/28 that of steel, so that working under ordinary conditions where the refinements of the most precise geodetic work are not necessary, a temperature correction can be neglected. The determination of the expansion of the invar and steel tapes involved a study of the constants of the comparator room itself, and it was found that the entire tunnel shrinks about six-hundredths of an inch in passing from a temperature of 100 degrees F. to 32 degrees F.

The work in the laboratory is so arranged that there can be measurements made each day, and there is a direct comparison of the tapes with the five-meter bar on each occasion. This bar, which has been used for many years, so that its constants are known with high precision, is of steel, with the terminals of the standard distance indicated by lines on platinum-iridium plugs. In testing invar tapes the tension used is 10 kilogrammes, while ordinary steel tapes of 100 feet are stretched at a tension of 10 pounds. The chief practical advantage of the invar tape is that its small coefficient of expansion not only simplifies measurements generally, but in particular, permits of accurate measurements being made in the daytime instead of at night, as is essential in using steel tapes in base-line measurement.

On the wall opposite the comparator is the 50-meter U. S. Bench Standard for testing ordinary steel tapes. This has been formed of five cold-rolled steel bars, about 33 feet in length, welded end to end with thermite. As previous to the welding the bars were well fitted and cleaned, the result is a continuous bar 165 feet in length. Not only are the terminal distances marked by platinum-iridium plugs with fine transverse lines, but at various regular intervals similar plugs are inserted, so that the intermediate distances on a tape can be verified with accuracy. These plugs are inserted every 10 feet for the tapes with the customary divisions, and every 5 meters for the metric tapes, the distances being correct at 62 degrees F. for the customary measures, and at 0 degree Centigrade for the metric scale. Ordinarily, the tapes are laid flat on the steel bar, but if desired they can be suspended

on small pins on the outside of the bar and the conditions of support arranged to simulate those in the field. The bar itself is free to move on rollers carried on brackets fastened to the masonry wall and spaced at intervals of 40 inches, so that not only is it kept hornzontal, but it is free to expand and contract with changes in temperature.

The Bureau of Standards not only tests metal tapes for the various government departments, but also for manufacturers and engineers upon payment of nominal fees, depending on the length of the tapes and the number of divisions examined. The charges range from 75 cents for tapes not longer than 100 feet, and supported throughout the entire length, to $2.25 for tapes 400 feet in length with comparisons at the 100, 200, and 300-foot divisions. If the tape is supported at intervals, the Bureau doubles the charge, while determining the coefficient of expansion, testing under different tensions, determining the modulus of elasticity, or other tests are made for suitable and reasonable fees.

The tests can be made as elaborate as desired, but in most cases it is sufficient to compare the tapes with the U. S. Bench Standard for the total distance and some of the more important subdivisions, as the coefficient of expansion of the majority of steel tapes is practically that of the standard steel bar—0.0000063 per degree Fahrenheit or 0.0000114 Centigrade—so that a direct comparison with the latter suffices and will afford an adequate determination of its accuracy for most purposes. If the tape in construction and tests complies with the requirements of the Bureau, it will be certified, and the Bureau of Standards test number corresponding to the number of the certificate issued will be stamped or etched on the tape.

Since the Bureau has undertaken the testing of tapes there has been an increase in the accuracy of those available for engineers, and there is no reason to-day for any one to have any uncertainty about the accuracy of his measures with the Bureau of Standards ready to make final and conclusive tests on payment of a small fee. In the year ending June 30, 1907, 135 tapes were submitted for test by engineers and surveyors in all parts of the country.

THE DIRECT PRODUCTION OF COPPER TUBES, SHEETS, AND WIRE.

Paper by Mr. Sherard O. Cowper-Coles read before the British Institution of Mechanical Engineers, July, 1908.

The numerous processes involved in the production of suitable copper and its subsequent conversion into copper sheets, tubes, and wire by a series of operations, such as rolling, drawing, and annealing, would occupy too much time to be referred to even briefly; therefore the author has limited the paper to the direct production of copper tubes, sheets, and wire by electrolysis from impure copper. The methods described are all based on the work of Davy and the law of electrolysis established by Faraday in 1833, namely, that when a current of electricity is passed through a solution containing metallic salts and two or more electrodes, one of which is soluble in the solution, a known quantity of metal is transferred from one electrode to the other for a given quantity of electric current; that is to say, if the soluble electrode (the anode) is connected to the positive pole, and assuming the metal and the electrolyte employed to be pure, a weight of metal will be deposited upon the cathode connected to the negative pole, corresponding to the amount dissolved from the anode. If the anode is of impure metal many difficulties are introduced, and if the current is increased to a sufficient density to enable the metal to be deposited at such a rate as will give commercial results, other serious difficulties arise. Electro-metallurgists have been working for thirty years or more devising methods to overcome the difficulties experienced in applying Faraday's law to the commercial production of copper tubes, sheet, and wire from comparatively impure copper having the physical properties of wrought copper, when deposited at a sufficiently rapid rate.

The refining of copper by electrolysis has now assumed vast proportions, and the annual output of electrolytic copper in the year 1907 has been estimated at 400,000 tons, equal to 56 per cent of the world's production, and the capital sunk in the industry at about £15,000,000. The whole of the copper thus produced is in the form of rough slabs or cathode plates which have to be smelted and worked to the desired forms. Electro-metallurgists have been striving for many years to devise a process which does away with the smelting of copper after it has been electrolytically refined, and to electro-deposit copper after the refining operation in such a form that it can be placed direct on the market as finished sheets, tubes, and wire.

The author, when carrying out some experiments on the production of copper tubes and sheets by electro-deposition on rotating cathodes, observed that when the speed was greatly increased, entirely new results were obtained, and that a current density of 200 amperes or more per square foot could be employed, the copper remaining smooth and having a tensile strength equal to the best rolled or drawn copper, and in some cases a tensile strength some 50 per cent higher than that obtained by the ordinary process of casting and rolling, the tensile strength increasing with the rate of rotation of the mandrel. The result of revolving a mandrel at a comparatively high speed is that every molecule, as it is deposited, is burnished or rubbed down so as to produce a tough fibrous copper, the usual order of things being reversed, the present practice being to put the mechanical work into a mass of copper by rolling or drawing instead of treating each molecule separately. This observation led to further experiments, which resulted in evolving the process now known as the centrifugal copper process for the manufacture of sheets, tubes, and wire, which will now be described in detail, together with the results obtained.

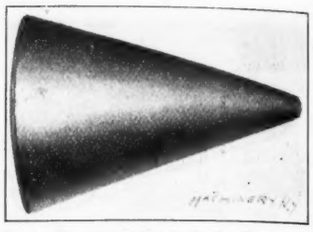


Fig. 1. Copper Cathode in the Form of a Cone to determine Critical Speed.

After a long series of experiments had been made to determine the best composition for the electrolyte and the most economical current density to employ, the critical speed was accurately determined by means of revolving cathodes in the form of cones, Fig. 1. By observing the point at which the copper remains smooth, and by measuring the circumference

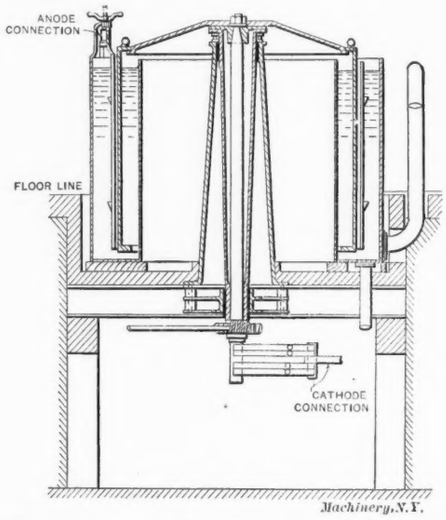


Fig. 2. Vat used for producing Copper Sheets by the Centrifugal Process.

of the cone at that point and multiplying it by the number of rotations per minute, the critical speed is readily determined; 200 amperes per square foot is found to be the most economical current density, although a current density up to 500 amperes per square foot can be employed by increasing the rate of rotation, but the increased cost due to increased voltage renders such a current impracticable for ordinary commercial work.

One of the chief difficulties inherent in any electrolytic or wet process for the production of copper tubes and sheets, is having any working parts, such as bearings, in an acid copper sulphate solution, and this was one of the first troubles en-

countered when working the centrifugal process on a commercial scale. This difficulty was eventually overcome by constructing vats in the form of an annular ring, as shown in Fig. 2. It will be observed that by such an arrangement all working parts are outside the vat and do not come into contact with the electrolyte, so that the bearings can be lubricated in the ordinary way; only the actual face of the mandrel on which the copper is to be deposited is immersed in the electrolyte. The cathode consists of a steel or cast-iron cylinder closed at one end, to which is attached on the inside a steel rod projecting below the edge of the mandrel to guide it into position; the cylinder can be 5 or 6 feet in diameter or even larger, so as to produce a copper sheet of say 20 feet long by 4 or 5 feet broad. Anodes, composed of crude copper, are placed around the mandrel with intervening spaces, and are fed forward by suitable mechanical means, as the copper dissolves away, so as to keep the voltage constant.

One great advantage of the centrifugal process is that a very low voltage is required even when employing a very high current density; for instance, only 0.8 of a volt is required at the terminals of the vat when working at a current density of 200 amperes per square foot of cathode surface. The effect of revolving the cathode is five-fold; it keeps the electrolyte agitated, so that there is always a fresh supply of copper ions in proximity to the cathode; each molecule of copper as it is deposited on the cathode is burnished or rubbed down by means of the skin friction between the revolving cathode and the electrolyte; the rotation prevents any foreign matter that may be in suspension in the electrolyte settling on the cathode and becoming entangled by further copper being deposited around or over it; it brushes away any air-bubbles on the cathode, which are the cause of nodules forming; and the rotation of the cathode ensures the thickness of copper being uniform, even when a mandrel of say 8 feet in length is employed.

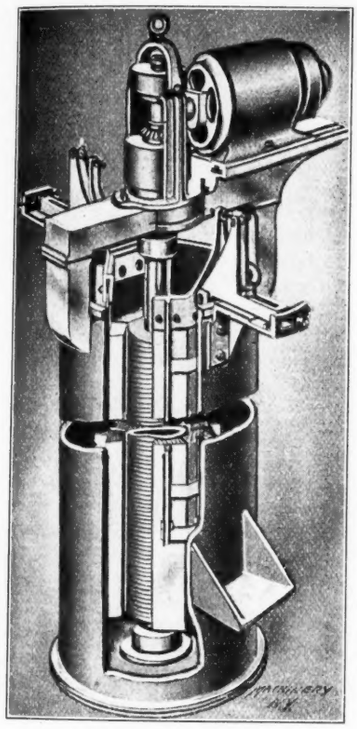


Fig. 3. Vat used when making Tubes by the Centrifugal Process.

The method of making tubes by the centrifugal process is as follows: A mandrel somewhat smaller than the finished internal diameter of the tube is prepared by coating it with an adhesive coating of copper by first depositing copper upon the surface from an alkaline solution and then thickening it up in an acid solution, the surface being highly burnished and treated chemically to ensure the easy removal of the deposited tube. The mandrel thus prepared is then placed in a vat as shown in Fig. 3. When the desired thickness has been obtained, the mandrel is removed and placed in a horizontal or vertical lathe, and a round-faced roller run over the surface so as slightly to expand the deposited copper, which can then be readily drawn off.

Copper sheets are prepared in a similar manner, the only difference being that the mandrels are of much larger diameter, and a narrow insulating strip is fitted down one side so that the sheet can be easily removed by inserting a tool under one of the edges of the deposited copper. It is no more costly by the centrifugal process to make thin sheets than thick ones; copper foil can be made in five minutes, direct from crude copper. Copper tubes produced by this process without any drawing, have given a maximum stress of 17 tons, and tubes after drawing have withstood a pressure of 3,000 pounds per square inch without showing any signs of distress. Sheets made without any rolling have given a maximum stress of 28 to 30 tons per square inch, according to the peripheral speed at which the mandrels were revolved.

The production of copper wire by electrolytic means is a more difficult problem than the production of copper tubes

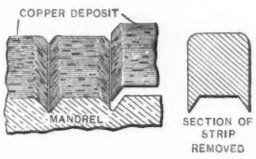


Fig. 4. Diagram showing Method of forming Weak Line of Cleavage due to Crystalline Structure.

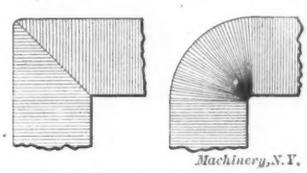


Fig. 5. Diagram showing the Effect of Sharp and Rounded Corners on the Crystalline Structure of Metal deposited on Mandrel.

and sheets. Various processes have been suggested and tried from time to time, such as the electro-deposition of copper on thin wire, until it has obtained a considerable thickness, and then drawing the thickened wire down to a comparatively fine wire. Experiments have been made with such processes, but so far they have not been worked commercially.

Copper wire is made by the centrifugal process in the following manner: A mandrel similar to that used for making copper sheets is employed, around which a spiral scratch is made, the pitch being determined by the size of wire required. The effect of the spiral scratch (which need only be very light, but must be angular), is to cause the crystalline structure of the copper to form a cleavage plane, as shown in Fig. 4. It will be observed that the copper divides exactly at the apex of the scratch, that is, the copper deposited in the scratch is equally divided and forms a small V-shaped fin on two sides of the copper strip. If the scratch is not angular, but rounded at the base, the copper will not divide, as the crystals are radial, as shown in Fig. 5. After the desired thickness has been obtained, approximating the pitch of the spiral scratch, the mandrel is removed from the depositing cell and placed in a vertical position on a special lathe, and the copper strip is unwound, as illustrated in Fig. 6, at an angle of about 45 degrees to the face of the mandrel. During the process of unwinding, the small fin or burr is removed by passing the wire through a suitable die and then through a wire-drawing machine provided with three or more drawplates to reduce the strip to the desired diameter. By employing a mandrel of 6 or 7 feet in diameter, lengths of wire 4 or 5 miles long can be made in one operation. Reference was previously made to this method of making copper wire in the November, 1905, issue of MACHINERY.

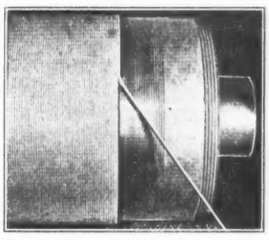


Fig. 6. Unwinding the Copper Strip from the Mandrel.

The advantages of an electrolytic process as compared to a smelting process are many, and the day is not far distant when copper will no doubt be leached direct from the ore and electrolyzed with insoluble anodes, to produce finished copper sheets and tubes in one operation direct from the ore without the intermediate process of smelting and refining. The centrifugal process is a step in this direction, as it is capable of depositing copper from its solutions by using insoluble anodes in the form of finished tubes or sheets in one operation. The centrifugal process is at least ten times faster than any existing electrolytic process, and a high current density can be employed without deteriorating the quality of the copper. The plant is simple and free from mechanical complications, and the amount of copper locked up for a given output is small compared to other processes. The process is of interest to mechanical engineers, as it conclusively proves that to get a high tensile strength in metals combined with ductility, it is not essential to put a large amount of work into the metals as hitherto has been considered necessary, by the processes of swaging, rolling or drawing, but that a very small amount of energy will suffice when applied in the manner described.

CUTTING AND KEYSEATING CHANGE GEARS ECONOMICALLY.

RAQUET.

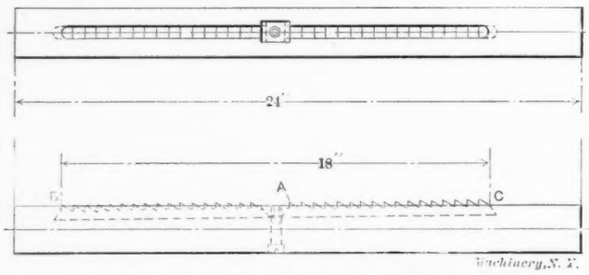
This article is a kind of appendix to the one on machining change gears which appeared in the April issue. Through information obtained later, I was rather surprised to learn that the method of broaching keyseats therein described was comparatively unknown in America. So I thought a bit more information might be acceptable.

Of course the "pull" broaching machine as made by the Lapointe Machine Tool Co. in America and Smith & Coventry in England, are well known examples of broaching machines, but I do not fancy either of them (from a casual knowledge of the machines) for keyseating change gears, because every time a gear or stack of gears has been operated on, the machine must be stopped to place another in position.

With the "push" method the machine runs continuously, it being comparatively easy to keyseat a gear at every stroke, the machine running at from 120 to 140 strokes (forward and return) per hour.

Another objection to the "pull" type when applied to this work is the difficulty of making the long slim cutters which must of necessity be made in one piece, whereas with the cutter bar, illustrated herewith, the cutters may be made in two or more parts. My previous article stated that the cutters were fixed to the bar by screws from the under side, but since that was written we have found a better way.

The objection to the first method is that the cutters must be exceptionally wide to admit of using reasonable size of



Bar with Inserted Cutters for Keyseating Change Gears.

screws. We have had a lot of trouble with the cutters breaking at the tapped holes, so after some study I evolved the one shown in sketch.

It will be seen that there are no holes in the cutters, so that they, therefore, may be made the same width as the keyseat to be cut. The beveled ends and the clamping arrangement at the center ensure a solid job and also make it possible to insert new cutters with very little trouble. Of course, it will be understood that the taper of the cutting edges from *B* to *C* is not a straight line from end to end. The presence of the clamping plate at the center necessarily does away with two or three of the cutting edges so that if *BAC* were all in the same straight line the tooth *A* would have two or three times too much stock to remove.

The largest bar we have at present is 1½ inch diameter for keyseats ⅜ inch wide, 3/16 inch deep, and 18 inches of cutting edges seems to be about right. Of course, the overall length of the bar is unimportant, but I should not reduce the length of the cutting edges for 1 inch bars for keyways ¼ inch by ⅛ inch and over.

While in my previous article I showed how we did the work on a planer, it would be far more convenient, where there is much small keyseating, to make a special machine. This machine would always be ready and it would then pay to keyseat even odd gears in this manner. A machine for this work is very simple and could be made very cheaply. All that is required is a gap lathe bed, a central screw driven by two belts (open and crossed), a reciprocating carriage driven by the screw, and a suitable bracket for the work to press against.

The cutter bars could be kept in close proximity to the machine; then if even a single gear required to be keyseated it would only be necessary to insert the correct size of bush, start the machine, mount the gear on the cutter bar, insert bar in end bracket, and the job is finished in less time than it takes to tell about it.

I think it would pay almost anyone to make a special machine in preference to rigging up a planer; but at the same time it must not be supposed that the machine would be kept constantly at work. It would take rather a big shop and a large number of gears to keep one of these machines in full employment, but an hour or two's run a day will be quite sufficient to pay a good percentage on the investment.

It should also be mentioned that the keyseats are kept up to size (depth) by putting tissue paper under the cutters.

Another point I should like to particularly emphasize is the importance of the method of indexing, christened block indexing for want of a better name, [Also known as multiple indexing—EDITOR] which was referred to in my previous article. I am firmly convinced that where the ordinary consecutive indexing method is in use on gears, say up to 6 diametral pitch, it is possible, by introducing block indexing, to increase the speed and feed so that the output is raised by fifty per cent. Not only this, but with the latter method and the increased speed and feed, the cutter and finished gear will be actually cooler than it would have been under the former conditions after doing an equal amount of work. The Brown & Sharpe Mfg. Co., in the book of instructions sent out with their gear-cutting machines, does not in my opinion attach sufficient importance to this method of indexing; they dismiss the question as follows: "The advantage claimed for omitting one or more teeth before cutting is the more even distribution of heat throughout the blank. On the other hand, however, good results can be obtained by arranging the speed and feed slow enough to avoid heating."

This was written a few years ago, before high-speed steel wakened up machine tool-makers. It was, no doubt, permissible then to "run slow enough to avoid heating," but now modern conditions demand that we should run as near the top speed and feed as we can get, finding ways and means of dissipating the heat generated.

Those mechanics who have never tried this method will be surprised to learn how the heat is dissipated by simply skipping a few teeth. At our works we would never think now of cutting change gears by the ordinary consecutive indexing method. The table (see Data Sheet Supplement) is exactly like the one we use with our B. & S. machine, but it is quite a simple matter to calculate one for any other make of machine. Suppose, for example, that the change gear table supplied with any particular machine gave the following change gears to index a certain number of teeth $\frac{20}{60}$ and $\frac{30}{50}$ (20 and 30 being drivers in both cases); then if we wish to cut say every fifth tooth (this depends on the number of teeth in the gear, it must not be a multiple) multiply the fraction $\frac{20}{60} \times \frac{30}{50}$ by 5. Then we have $\frac{20}{60} \times \frac{30}{50} \times \frac{5}{1} = \frac{1}{1}$ In this particular case equal gears would divide the blank so that every fifth space was cut.

I notice in the series of articles "Gear-Cutting Machinery," which have recently appeared in these columns, that one machine (February, 1908, engineering edition), by J. Parkinson & Son, Shipley, England, is specially arranged for block or multiple indexing, but as shown above, nearly any machine can be set up with very little trouble, though, no doubt, there would be some difficulty with the smaller pinions; but block indexing does not make as much difference when the gears to be cut have only a small number of teeth, so that it is not really a very serious difficulty after all.

* * *

The largest apartment building in the world will be built in New York City, on Broadway and Amsterdam Avenue, between 86th and 87th Streets. It will cover the entire block and will be 350 feet long, 200 feet wide and 150 feet high. It will be twelve stories in height, and will have 175 apartments, containing from nine to fourteen rooms each. The building will be constructed in the form of a hollow rectangle, the courtyard in the center being 250 x 100 feet wide. The structure will cost $3,000,000.

THE STRENGTH OF HELICAL GEARING.*

It has long been possible to produce a double helical form of cut gearing by bolting together a pair of spiral wheels of opposite hand, but this method of construction is far from satisfactory on account of the extreme difficulty of bringing, at anything like a reasonable cost, the two sides into accurate register. About five years ago Herr Wüst, of Zurich, conceived the idea of generating both sets of spiral teeth in a single-wheel blank by using two hobs of opposite hand to cut the teeth simultaneously. The difficulty was to find means whereby the teeth on each side could be cut through to the center. This difficulty was, however, solved when the teeth were staggered, so that the centers of the teeth on one side of the wheel coincided with the centers of the spaces between the teeth on the other side. Wheels and pinions of this form are now manufactured by the Power Plant Company, Limited, West Drayton, Middlesex. The result of the method adopted by this firm will be better understood on reference to Fig. 1, which is a reproduction of an actual pinion of seven teeth which was cut in this way. Not only have wheels so made proved quite satisfactory, but they have been found to possess the advantages incidental to the old stepped type of gearing, *viz.*, greater freedom from backlash and shock; and machine-cut double helical gears of this type are far stronger than straight-cut gears of equal pitch and width. The capacity of a gear-tooth to transmit power depends on the metal section available at the base to resist the maximum bending stress. In the case of ordinary straight-spur gears, the teeth are subjected to greatly varying bending stresses while in engagement, and the maximum stress on a driven tooth occurs when a driving tooth first engages it at the extreme tip. The bending stress is then proportional to the product of the driving force into the height of the tooth.

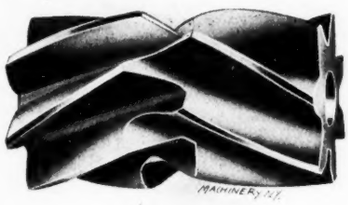


Fig. 1. A 7-tooth Herringbone Gear formed by the Wüst Process.

With double helical wheels the conditions are much less severe. What is meant will be understood on reference to Fig. 2 below, which shows in development a portion of the rim of a wheel of 50 teeth, having staggered double helical

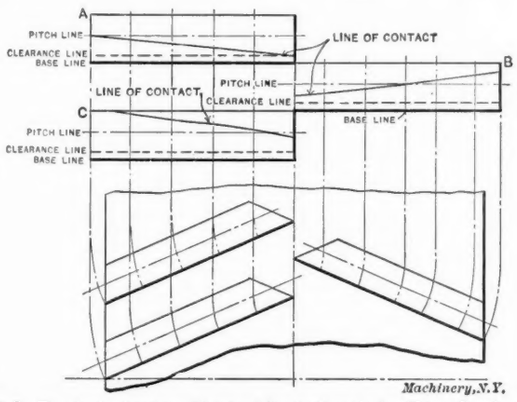


Fig. 2. The Instantaneous Lines of Contact made by Three Contiguous Teeth with their Mating Teeth.

teeth cut at 23 degrees, and a width equal to five times the circular pitch. The three teeth, *A*, *B*, and *C*, are all in engagement at the same time, and the normal elevations of these teeth are shown. The wheel of 50 teeth is considered to be driven by a pinion of 25 teeth, and the representation is made at the moment when the center of tooth *B* is engaged at the pitch line. In order to make a comparison with straight spurs it is necessary to average the contact across the three teeth *A*, *B*, and *C*. This is shown by the horizontal lines in Fig. 3, which are obtained by averaging the ordinates of the contact lines in the upper view of Fig. 2. On comparison of Figs. 2 and 3, it will be noticed that the average contact for *A* is at its lowest and *C* at its highest, while the average for *B* is about the pitch-line. As the wheels roll on, these average contact lines change in position, but on any one tooth they never rise above the level shown for *A* in Fig. 3, nor fall below that for *C* in the same figure. Thus for every tooth there is a zone within which the limits of average contact

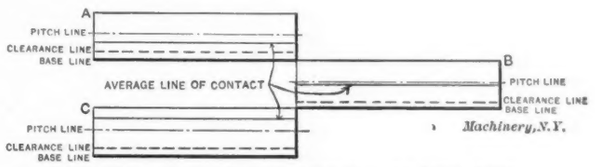


Fig. 3. The Average Lines of Contact on the Three Teeth.

must lie, as illustrated by Fig. 4. Here the shaded portion *Y* shows the variation of average contact for the case under consideration, while *X* is the working height of the tooth. For teeth cut at 23 degrees to the axis, on a wheel whose width is five times the circular pitch, *Y* equals about $0.44X$ for a wheel of 50 teeth driven by a pinion of 25 teeth.

Fig. 5 shows the corresponding variation of contact, and of bending stress, in a straight-cut spur-wheel under similar conditions. It will therefore be seen that the reduced variation of stress allows the employment of much finer pitches, for equal powers and speeds, than are permissible for straight-cut gears.

The particular case considered is merely given for illustration, but the same method of comparison holds good for any combination. In general, the variation of bending stress on double helical staggered teeth is less than in the case considered, because the comparatively fine pitch employed usually leads to wheels of many teeth, the number being rarely less than 100, and rising sometimes to 500. Another advantage claimed for these helical teeth is that their gradual engagement tends to eliminate shocks, and this effect is increased by

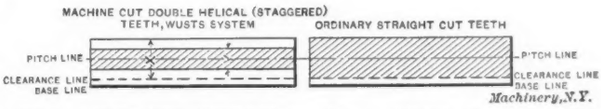


Fig. 4. Shaded Area shows Range of Average Line of Contact on Herringbone Tooth.

Fig. 5. Shaded Area shows Range of Line of Contact on Spur Gear Tooth.

the stepped form of teeth adopted. The smoothness of running, which is the direct outcome of these special features, consequently makes it possible to produce noiseless gears without having recourse to intrinsically weak pinion materials, such as raw hide, or fiber.

[The form of gearing here shown is that produced by the Wüst machine, described in the April, 1908, installment of the series of articles on gear-cutting machinery which we have just finished. The great advantage of this form of herringbone gearing would seem to be the possibility of producing it at a reasonable cost. We do not understand the difficulty mentioned in the above article of bringing the two sides of a split gear of this style into accurate register. If the two sides are not in accurate register, the pinion will float sideways on the gear slightly until it is in engagement equally on each side. The shaft should be left free for end-wise movement for this purpose, and no collars are necessary. We are not, furthermore, inclined to believe that the staggered form of tooth is of any advantage whatsoever, except as it facilitates manufacture. The herringbone gear itself has the effect of a stepped gear of an infinite number of steps, so it is perfect in this respect, and staggering the teeth cannot make it any more perfect.

The main subject matter of this article, however, relating to the strength of helical gearing, is new so far as we know. It is evidently a fact that helical gearing is stronger than spur gearing of the corresponding size, owing to the fact that at no time is the whole breadth of any one tooth subjected to the maximum pressure, that pressure occurring only at one point. —EDITOR.]

* * *

Don't tell what you would do if you were someone else—just show what you can do yourself.—*Speed.*

* From an article entitled "Machine-cut Double Helical Wheels" in *Engineering*, February 21, 1908.

OXY-ACETYLENE PROCESS OF METAL CUTTING AND AUTOGENOUS WELDING.*

Within the past seven years a valuable tool, unique in its characteristics, has been developed for cutting, shaping, and welding metals, in the oxy-acetylene "torch," which now is so well advanced that it bids fair to displace other emergency cutting and welding means to a large extent. The oxy-acetylene process had its inception in France, the first experimenter being Mr. Edmund Fouche, of Paris, who began his work on it in 1901. The principle of the oxy-acetylene torch or burner is essentially the same as that of the oxy-hydrogen blow-pipe,

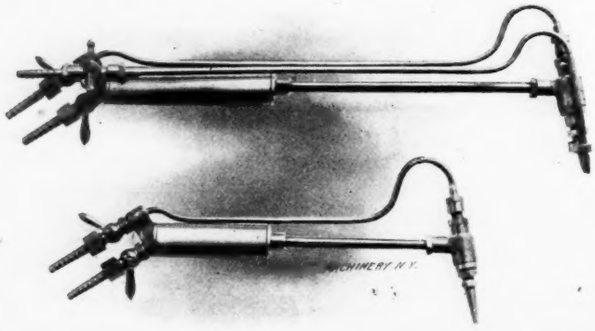


Fig. 1. Davis-Bournonville Oxy-acetylene Cutting and Welding Torch.

which has been used for many years for generating intense heat. But though the oxy-hydrogen flame is intensely hot, the flame produced by the oxy-acetylene torch is so much hotter that the two are not in the same class. The temperature produced by the oxy-hydrogen flame is rated by authorities at about 4,000 degrees F., while that of the oxy-acetylene flame is estimated at about 6,300 degrees F. Not only is the flame of acetylene much hotter than hydrogen, but the number of B. T. U. per cubic foot is about five times as great, being as 330 to 1,600. Hence both the intensity and amount of heat is greatly increased in the flame of the oxy-acetylene torch. A comparison between the two instruments has been aptly put as like that of "a finely pointed-tool and a blunt instrument."

While the temperature of the flame of the oxy-hydrogen torch is high enough to melt and even vaporize most commercial metals, when the heat is confined, it is not high enough

Fig. 2. Samples of Steel and Cast Iron Welding, and Cutting done with Oxy-acetylene Flame.

to fuse the edges of metals and make autogenous welding commercially profitable. At least this appears to be the case in the present development of the art. The rapid radiation and conduction of heat away from the joint prevents perfect fusion and joining, but with the vastly hotter oxy-acetylene flame, autogenous welding becomes easy and rapid. Even aluminum, which conducts heat away with great rapidity and can be locally fused with difficulty, yields to the oxy-acetylene flame and joins perfectly, the joint being entirely homogeneous. In fact, the autogenous weld thus produced is the only known method of joining aluminum that will not separate with use.

The commercial development of metal-cutting and autogenous welding has been taken up by several concerns in the United States and Europe. The processes are essentially the same, the difference being in the construction of the torches and the manner in which the gases are generated. Great difficulties have been met in cheaply producing pure oxygen gas. The cheap production of acetylene had, to a great extent, been satisfactorily solved in the extensive development of acetylene lighting, but even this art had to be further developed to meet all the requirements of metal welding and cutting work. There are four or five commercial means of making oxygen, these being principally the oxone or barium process, the liquid air process, the epurite process, and the chlorate of potash process. The latter process is used by the Davis-Bournonville Co., New York, and the following notes relate to the development of the art of metal cutting and autogenous welding, as reached by this concern.

The chlorate of potash process of generating oxygen is well known, being perhaps the simplest method. It will be found described in elementary works on chemistry. The oxygen of chlorate of potash can be driven off by gentle heat, and, in practice, the potash is placed in a closed retort and subjected

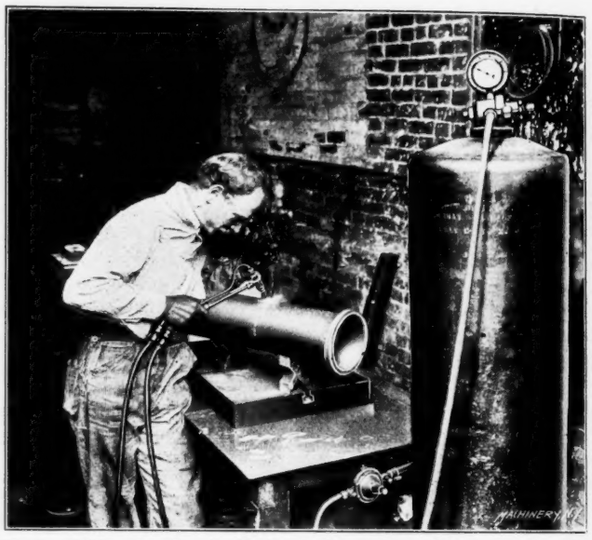


Fig. 3. Welding together the Parts of a Drawn Steel Retort. The Operator feeds the Joint with a Special Grade of Iron Wire.

to a comparatively low temperature. The reduction is facilitated by the addition of black dioxide of manganese in the proportion of 14 pounds of manganese to 100 pounds potash. The oxygen gas is passed through scrubbers and is pumped into receivers. The pressure in the receivers is varied according to the use, it being desirable to compress from 125 to 150 pounds per square inch for metal cutting, while 15 pounds pressure suffices for autogenous welding. The acetylene gas is produced in the Davis generator which is adapted to all pressures up to 15 pounds per square inch. The machine is automatic and feeds lump carbide perfectly up to sizes that pass through 1-inch screen. The theoretical quantity of water to carbide is about ½ pound to 1 pound carbide, but to absorb the heat of the chemical transformation the generator is required to have a water capacity of 1 gallon water to 1 pound carbide. For repair shops and work outside of the shop, a portable apparatus is required, and for such purposes the oxygen and acetylene gases are stored in small cylinders. The storage of oxygen is a simple matter of pumping the gas into the cylinders until the required pressure has been reached. The storage of undiluted acetylene under pressure in tanks is impracticable, but fortunately, it was discovered in 1896 by Claude and Hesse, two French engineers, that acetone, a fluid derived from the dry distillation of wood, is a remarkable solvent for acetylene, being capable of absorbing 25 times its volume at 60 degrees F. for each atmosphere. At ten atmospheres, or 150 pounds pressure per square inch, a gallon of acetone absorbs 250 gallons of acetylene gas. When absorbed by acetone, acetylene is non-explosive under heavy pressure.

*For previous articles on autogenous welding, see "Blow-pipe Metal Welding with Acetylene," March, 1904; "Acetylene Gas for Welding," September, 1906; and "Autogenous Welding," July, 1907. For articles on storage of acetylene gas in acetone, see "Acetone as an Absorber of Acetylene Gas Under Pressure," December, 1903, and "The Acetylene Safety Storage System," August, 1904. For article on oxygen cutting, see "The Use of Oxygen for Removing Blast Furnace Obstructions," July, 1906.

A red-hot wire might be thrust into the receiver with absolutely no effect, provided there is no free space occupied by acetylene gas. To prevent the possibility of there being free spaces for the accumulation of gas, acetylene storage tanks were designed by Mr. Edmund Fouche, which are packed with porous brick, asbestos or other neutral porous material, thus filling the entire free spaces and affording storage for the acetone and acetylene gas only in the cells of the filling.

Fig. 1 shows the Davis-Bournonville Co.'s cutting and welding torches. The upper illustration is the cutting torch and differs from the welding torch shown in the lower illustration simply in that it has an auxiliary detachable oxygen tube secured to the side. The welding torch has an acetylene gas tube and an oxygen tube which combine in a tip or nozzle from which the united gases flow and burn. The upper tube in each illustration is for oxygen, while the lower tube is for acetylene, the two gases uniting at the end of the removable tip within the body of the torch. The enlarged portion of the torch in the acetylene pipe is packed with porous material to prevent flash-backs extending beyond the torch itself.

Samples of welding and cutting are shown in Fig. 2. The pieces at the left are parts of two steel strips which were welded edge to edge. The welded piece was cut in two and the lower specimen shown was bent over on the weld through an angle of about 120 degrees. The ground parts on the left end of each piece indicate a perfectly homogeneous union. The piece in the lower right-hand space is made up of cast iron and steel welded together. The cast iron is welded to itself as indicated in the illustration, and to the steel, the union in each case being perfect. However, because of the difference in expansion and contraction, there is danger of a crack appearing in cast iron welded to steel unless it is carefully cooled off. Right here it might be said that expansion and contraction are the greatest foes of antogenous welding, and to effect satisfactory work on some pieces, it is necessary to raise the temperature by pre-heating before welding is commenced. Then the difference in temperature of the welded and unwelded parts is not so great. Moreover, this practice has the advantage of saving gas that otherwise would be required to heat adjacent parts before fusion is reached.

The upper right-hand piece shown in Fig. 2 is a sample of ½-inch steel plate cut out with the cutting torch. The piece illustrated is shown reduced to about one-half the actual size, and it gives an idea of the width of kerf, the kerf being about ⅛ inch wide. Cutting steel with a torch is much more spectacular and impressive than welding, the metal being cut away rapidly and passing off in scintillating sparks. The work is done with comparative rapidity. A No. 1 tip will cut up to ½-inch steel at the rate of 60 feet per hour, with a consumption of 12 cubic feet of acetylene and 15½ cubic feet of oxygen in the heating jet and 60 cubic feet of oxygen in the cutting jet. The cost of operation with labor at 30 cents per hour is estimated at $2.68, or about 4½ cents per lineal foot. The oxygen for the heating jet is carried at 14 to 18 pounds pressure, while the pressure of the oxygen cutting jet supply is much higher, being about 125 pounds pressure. Only one oxygen cylinder is required, however, the low-pressure welding flame supply being taken from the high-pressure supply and regulated by a reducing valve.

Fig. 3 illustrates the welding of thin steel retorts used for generating oxygen gas. The material for the retorts is brought in drawn shape, one part being made with a collar and the other having a rounded bottom. The length of the retort is too great to permit it being drawn in one piece, hence the necessity of welding the two parts together near the center. The following is an approximate cost of welding 1/16-inch metal. The consumption of acetylene is 2.8 cubic feet per hour; of oxygen 3.6 cubic feet at a pressure of 8 to 10 pounds. The rate of welding is about 50 feet per hour, and with labor at 30 cents per hour, the total cost per hour is 43.6 cents, or less than 9/10 per cent per lineal foot. The cost of welding increases with the thickness of material, of course, reaching an estimated cost of 37 1/2 cents per lineal foot for 7/16- to ½-inch thick metal.

In Fig. 4 is illustrated the welding of a broken flange on a casting. This job, which would have been difficult and expensive by brazing, was easily accomplished. In this illustration, as in Fig. 3, the operator is shown feeding material into the weld, the same as a tinner feeds solder when soldering. For welding steel and wrought iron a special iron wire is used, and for welding cast iron, rods of cast iron.

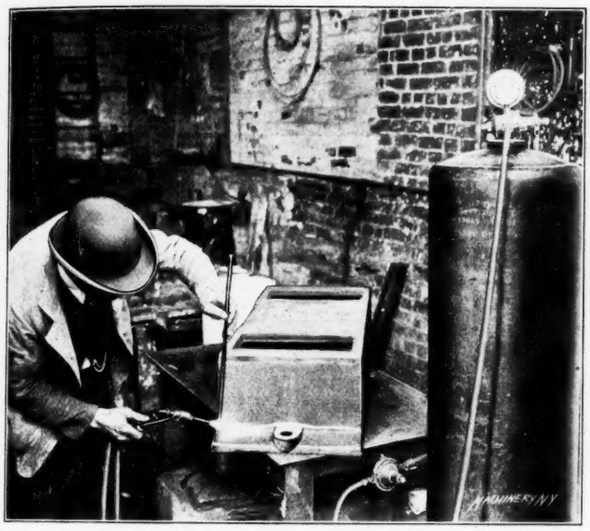


Fig 4. Welding the Broken Flange of a Cast Iron Base. The Operator feeds the Joint with a Cast Iron Rod.

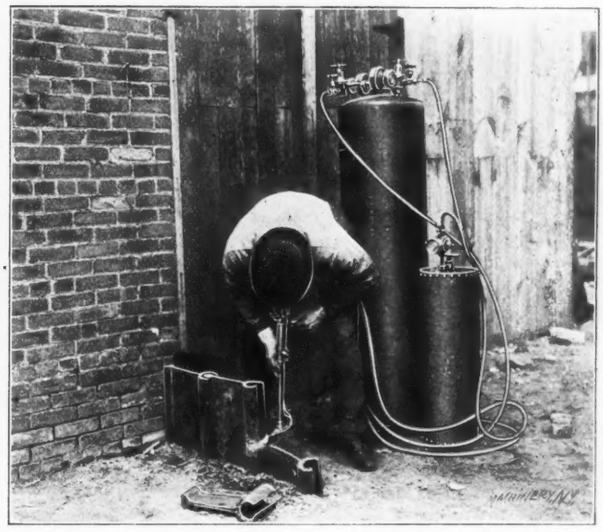


Fig. 5. Cutting Off Steel Sheet Piling with Oxygen Cutting Torch showing Portable Apparatus.

Fig. 5 illustrates the use of the cutting torch cutting off steel sheet piling. This work, as before stated, is done with rapidity, and is a very spectacular performance. In the case of cutting, the combustion of the steel materially raises the temperature and assists in the work. This was pointed out by Chevalier C. de Schwarz in a paper read before the May, 1906, meeting of the Iron and Steel Institute, and it gives one a startling idea of the power of the oxygen cutting flame when the concentration of the heat units produced is known. Burning 1 pound of acetylene with oxygen produces from 18,250 to 21,500 B.T.U. The mean value may be taken as about 19,750 B.T.U. per pound, and the number of cubic feet at atmospheric pressure at about 14½. Now, the burning of 1 pound of steel with oxygen produces approximately 2,970 B.T.U., but at atmospheric pressure 1 pound of acetylene gas fills 6,750 times the space of 1 pound of steel. Hence, the intensity of the heat with perfect combustion of the steel in oxygen will be, theoretically, $\frac{6{,}750 \times 2{,}970}{19{,}750} = 1{,}015$ times the intensity of heat of the oxy-acetylene flame. As a matter of fact, of course, this enormous temperature is not even remotely approached, because the metal dissolves at a far lower temperature and passes off in sparks, which are speedly cooled by the atmosphere.

F. E. R.

DEVICES FOR GRINDING FLUTING CUTTERS.

ERIK OBERG.*

In the January issue of MACHINERY a contributor described a simple device for grinding angular cutters. The principle embodied in this device is used in almost all devices for grinding angular cutters, or formed cutters having regular milling cutter teeth. In the case of formed cutters with regular milling cutter teeth, it is, of course, necessary that the teeth be ground around the edges instead of the teeth being only ground on the faces as is the case with eccentrically relieved teeth. In Fig. 1 are shown two types of milling cutters which may be ground with devices working on the principles indicated and described below. The cutter *A* is a regular fluting cutter for taps, and the cutter *B* is a formed fluting cutter.

In Fig. 3 is shown the device used for grinding a tap fluting cutter. The angle included between the two faces on the fluting cutter is 85 degrees, and the angle between the two faces *C* and *D* in the device for grinding the teeth of these cutters is also 85 degrees, one side making 30 and the other 55 degrees with a line at right angles to the axis of stud *A* on which the cutter is mounted while grinding. The device consists of a base-plate *G*, having three feet which rest on a special table on the grinding machine, shown in Fig. 5, which will be more fully described later. On this base-plate *G* slides a cutter holding slide *H*, which has a groove in the bottom, fitting a tongue projecting from the base-plate. An oblong slot is provided in the base-plate as shown at *P*, so that the slide *H* can be clamped to the base-plate by the screw *L*, at any place within the length of the slot. The screw *K* passing through the lug *R* driven into the base-plate *G*, and acting upon the slide *H*, permits the necessary adjustment. The slide *H* holds a stud or spindle *A*, passing through a projecting standard *F* of the slide. The cutter to be ground is mounted on this stud.

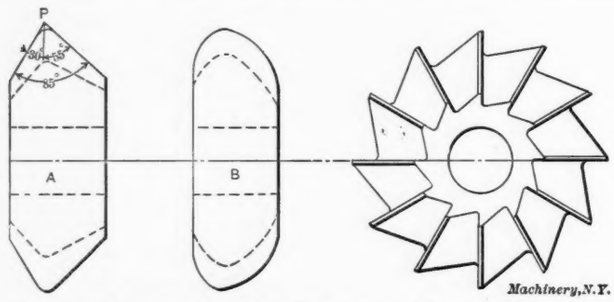


Fig. 1. Shape of Regular Tap and Formed Fluting Cutters.

It will be evident upon explanation of the action of this device in grinding the cutters, that these must be so mounted upon the stud *A* that the apex of the included angle between the two angular faces (that is, the point *P*, Fig. 1, where the angular sides would meet if extended) shall be on the same center line as the point *N* of the grinding fixture, where the two sides *C* and *D* meet (see Fig. 3). In order to obtain the fine adjustment necessary to bring these two points on the same center line, that end of stud *A* which enters in the bearing in the standard *F* is provided with threaded portions on which adjusting nuts are mounted. Collars are placed on the smaller diameter of *A*, against the shoulder *M*, so that the adjustment necessary to be made by the nuts will be comparatively small, the collars taking up the main difference in width of the various cutters to be ground. On the outside end of the stud *A* is a collar *B*, and a set-screw, having a large round slotted head, which is used for binding the collar against the cutter. It will be noted that this collar is cut off on one side to an angle. This is done in order to permit the collar to clear the emery wheel of the grinder when the side of the cutter tooth next to the collar is being ground.

As shown at *A*, in Fig. 1, the cutters to be ground have their two faces connected with the small radius, different for different kinds and sizes of fluting cutters. This radius is obtained by permitting the faces of the cutter teeth to project slightly outside of the faces *C* and *D* of the base-plate *G*, Fig. 3, when the cutter is in position on the shaft *A*, the point *P* of the cutter, however, still being in line with the point *N* of the device, as mentioned above. When in use, the grinding device is placed on the table of the grinding machine, as shown in Fig. 5. This table is mounted directly on the grinding machine knee, and is provided with a guide strip *E*. The hardened shoe *N*, in Fig. 3, slides against this guide strip *E* in Fig. 5, and by swinging the device around so that first the face *C* comes along the guide strip *E*, and then turning it around the point *N* until the face *D* rests against the guide strip, the cutter is ground to the same angle as that of the base-plate *G* in Fig. 3, and a radius will be formed at the point of the cutter, its length depending upon the distance the faces of the cutter teeth project outside of the faces *C* and *D*. Different angles may be obtained by putting tapered strips along the sides *C* and *D*, the angle included between the faces of the strips being the same as the angle between the faces of the teeth of the cutter. The base-plate for this device should be made of machine steel, and the faces *C* and *D* should be case-hardened. If tapered strips are screwed onto the faces *C* and *D* to accommodate other angles than the ones referred to,

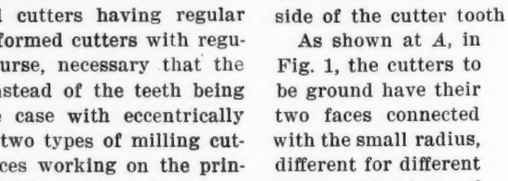


Fig. 2. End View of Formed Fluting Cutter Grinding Device.

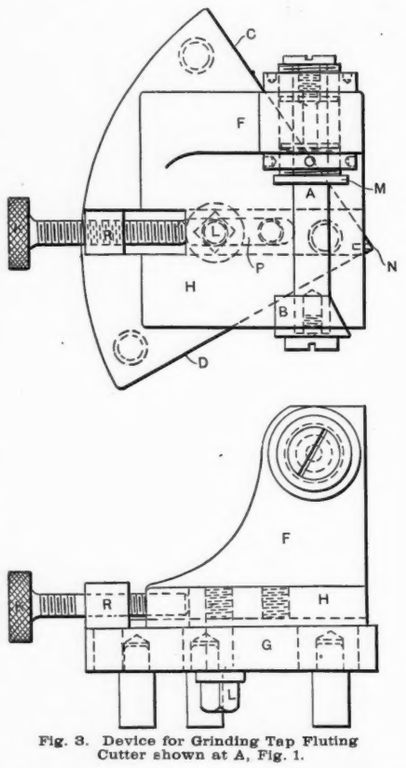


Fig. 3. Device for Grinding Tap Fluting Cutter shown at A, Fig. 1.

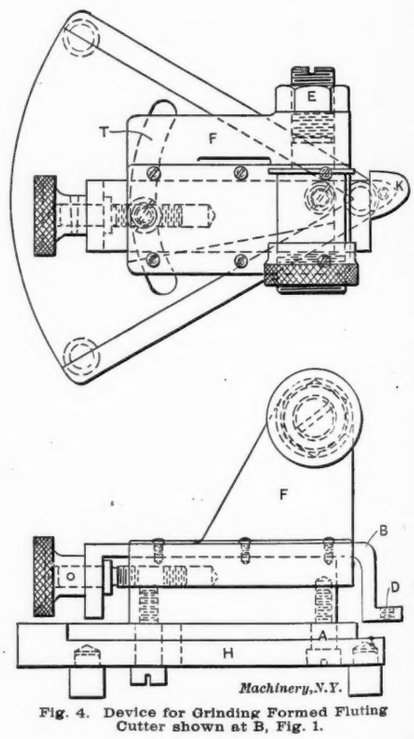


Fig. 4. Device for Grinding Formed Fluting Cutter shown at B, Fig. 1.

* Associate Editor of MACHINERY.

these strips should also be made of machine steel and case-hardened. Slide *H* is made of cast iron.

The engraving, Fig. 5, shows the special table, previously mentioned, on the cutter grinding machine. This table consists of a cast iron body, provided with two tool steel plates *S* on the top, forming the table surface. These plates are hardened and ground to prevent too rapid wear as the feet of the grinding device constantly slide on their top surface. The guide strip *E* is also made of tool steel and hardened.

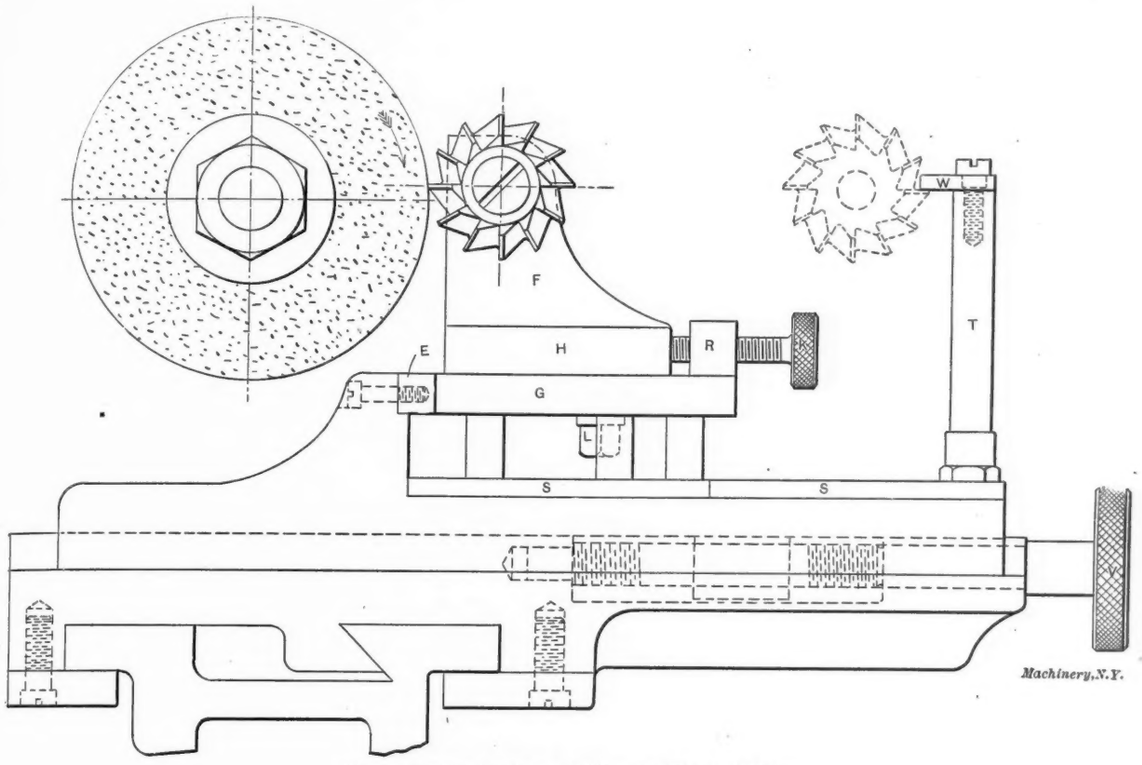


Fig. 5. Grinding Device for Cutters, on Table of Grinder.

At *T* in Fig 5 a stud is shown projecting up from the top of the table. From this stud extends an arm *W*, which is used for setting the cutter tooth, as shown, the cutter being indicated by dotted lines. It is, of course, necesssary that each tooth be exactly at the same height as the others, when ground, so that the diameter of the cutter measured over any two teeth will be exactly the same. The cutter is held simply by frictional resistance, and the indexing around is done by hand by the operator. The table can be fed out and in, by means of a feed-screw with a knurled head *V*, thereby permitting a greater or less amount to be ground off from the teeth of different cutters.

In Fig. 6 is shown a device which is used for setting the slide *H* in Fig. 3 to such a position that the correct radius will be ground at the apex of the angle of the cutter teeth. The stud *C* is screwed into the top of any kind of a base- or surface-plate. This stud has a slot or groove cut in its top surface, and a regular 4-inch machinist's scale, preferably graduated in 100ths or 64ths of an inch, is laid in this slot at the top and held by means of the set-screw *B*, the upper part of the round stud *C* being split so that the scale can be gripped in the slot cut for it, as if placed in a split chuck.

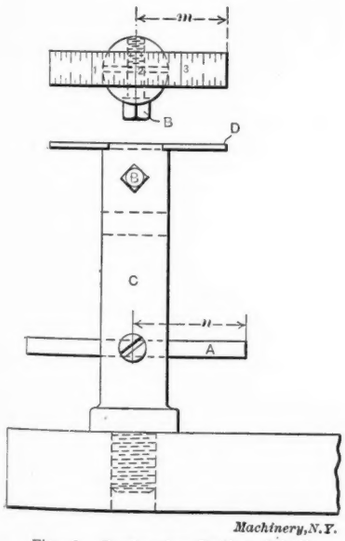


Fig. 6. Device for Setting Grinding Fixtures to grind a Certain Radius at Point of Cutter.

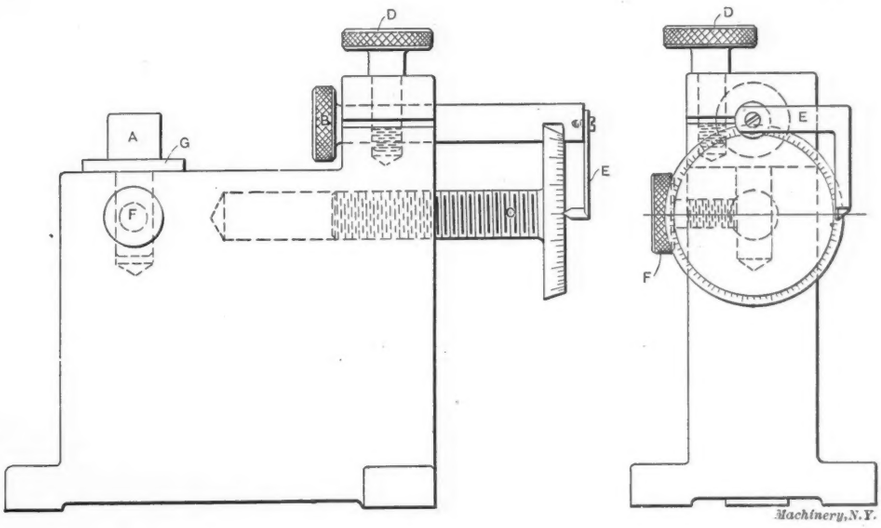


Fig. 7. Gage for Fluting Cutters.

When the device in Fig. 3 is to be set so as to grind a certain radius, the pin *A*, Fig. 6, is placed against the edge of the point *N* in the base-plate *G*, Fig. 2, and the slide *H* is adjusted so that the cutter touches the end *D* of the scale in Fig. 6. When the scale is so set that *m* equals *n*, the cutter to be ground will have no radius, but will have a sharp edge at the point. When *m* is shorter than *n*, the difference between

n and m will give a relative measure of the radius that will result between the faces of the cutter teeth; but it must be understood that this difference does not give the exact radius. This would be measured from the side D of the plate G to the side of the cutter. Of course, the arrangement in Fig. 6 may be used for measuring this length also, by placing the face D against pin A, and the angular side of the cutter tooth against the end of the scale.

The device in Fig. 7, finally, is used for inspecting the cutters when ground. The cutter is placed on the stud A, the stud entering the hole in the cutter, and the gage pin B, having a large head ground flat, is pushed up against the ends of the teeth in the cutter. This permits not only the length of the different teeth in the same cutter to be gaged, but in cases where several cutters are used in a set for fluting taps, all the cutters in the set can be gaged to find out if they are of exactly the same diameter. The gage stud B is fed in and out by means of the micrometer screw C, having a graduated head as shown. When the stud B has been set to the size of one cutter in the set of cutters, it is clamped in place by the clamp screw D. If, however, the other cutters in the set should prove to be smaller or larger than the first cutter, the clamp screw D can be loosened and the micrometer screw adjusted so as to move B in the desired direction, and the amount that the cutters are smaller or larger than the size of the other cutters in the set can be determined by reading off the number of thousandths directly on the graduated head of the micrometer screw C. This head should be graduated so that each graduation reads 0.001 inch. A pointer E is screwed to the end of the gage stud B, for enabling correct reading of the graduations. Collars may be put on stud A to accommodate smaller or larger thicknesses of cutters, or the binding screw F may be loosened and the stud A moved up enough to accommodate thinner cutters, the cutters resting on the shoulder G.

In Fig. 4 is shown a device used in conjunction with the grinding table Fig. 5 for grinding the shape of formed fluting cutters, such as shown at B in Fig. 1. The principle of this device is practically the same as that in Fig. 3. It will be noticed, however, that in order to permit the device to be swung around so as to grind the complete form of the fluting cutter, a slot T, cut on a circular arc, has been provided in the base of the device, and the top portion is swiveled around the stud A. At the front end of the slide B, a threaded hole D is provided for the screw which holds the former for the various drill fluting cutters to this slide, the slide being adjustable to take care of the different diameters of the cutters. In Fig. 2 is shown a side view of this device, which plainly shows the design of the cutter holding slide, the arbor, and its adjustment. It will be noticed that in this case, instead of adjusting the cutter arbor by means of two nuts, on each side of standard F, the stud C has the smaller end threaded directly into the upright F and the nut E simply acts as a binding or check nut. A slot is provided for a screw-driver in the end of the stud C to facilitate adjustment. It will be noticed that in the device in Fig. 4 the former is not attached directly to the base of the device, but is placed on an independent slide. On account of this, there is no need of having any sliding adjustment between the base H of the device and the standard F, all adjustment being taken care of by the slide B, having the formers attached at D, as mentioned. The general shape of the formers used is shown at K.

* * *

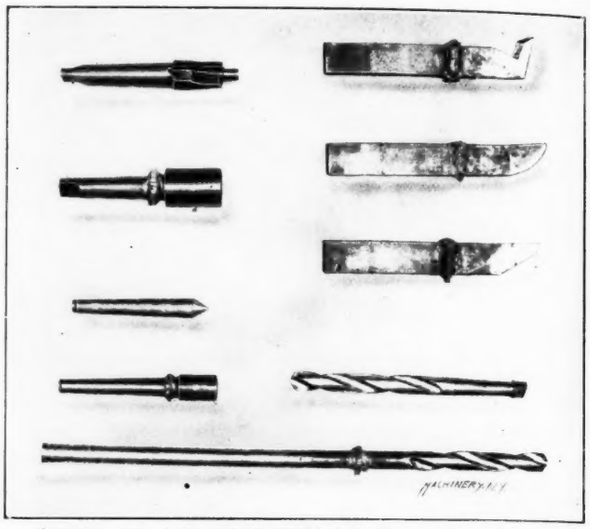
The experiments undertaken by various inventors for obtaining a satisfactory solution to the problem of wireless telephony seem to be crowned with success. In a previous issue we referred to the achievements of Valdemar Poulsen, the Danish inventor. Three French naval officers have now succeeded in constructing an apparatus by means of which they have, according to the *Petit Parisien*, been able to distinctly hear talking and singing over a distance of 90 miles.

* * *

Once in a while a concern hustles so everlastingly to beat a competitor that it works itself out of business. Success is not necessarily in beating the other fellow but in serving your own trade so well that it finds you indispensable.

ELECTRIC WELDING OF TOOLS.

The accompanying illustration received from the Thomson Electric Welding Co., Lynn, Mass., shows samples of electric welding which are of special interest to machine shop managers, foremen, and others interested in economical shop practice. They illustrate the economy in the use of high-speed steel, made possible by the electric welding process. The upper left-hand figures show a counterbore made with a carbon steel shank and high-speed cutting part electrically welded thereto. Below these views are views of a lathe center with carbon steel shank and high-speed steel tip, before and



Samples of Tools Electrically Welded for Economy of High Speed Steel and to effect Repairs.

after finishing. In the same illustration are shown diamond point, side and turning lathe tools of high-speed steel welded onto carbon steel or machine steel shanks.

A twist drill broken in the shank can be repaired by welding on a new piece, and with high-speed twist drills, the saving in expense is considerable. The process is also advantageous in making extension drills. The ordinary practice is to weld on a wrought iron shank or to insert a wrought iron filling piece, because of the difficulty of making welds in steel. The electric welding process makes it possible to weld on carbon steel shanks which, of course, are stiffer and stronger than wrought iron. The figure directly below the lathe tools shows a twist drill with a repaired tang, the tang having been twisted off and replaced by another tang electrically welded.

* * *

Mr. G. Scott Ram, electrical inspector of factories in Great Britain, has called attention to the danger of electric hand lamps of certain construction. In some lamps a brass tube is introduced inside of the handle as a chamber for the wire, and the flexible wire is nipped between the porcelain and the end of the brass tube at the lower end. The insulation of the wires is often scraped off far enough to bring it in contact with the brass tube, and as this latter is not always completely covered by a non-conducting handle the danger in handling the lamp is obvious. If a person holding such a lamp happens to be standing on a metal floor or on damp ground, or is otherwise in connection with the earth, he may get a severe shock, and in all probability he will be unable to release his hold of the lamp, and serious results will ensue. The two most important points to be borne in mind in the design of a lamp which can be used without danger is that there should be no metallic connection between the lamp holder and any other metal part of the fitting, and that the flexible wires in passing from the lamp holder shall not be taken through a metal tube, or otherwise in any way come in contact with any metal part of the fitting. In buying electric hand lamps, customers should carefully examine the construction and see that it agrees with the rules laid down above. Here is a case where simple common sense and no extra expense will add greatly to the safety in the industries where hand lamps are required to be used.

MACHINE SHOP PRACTICE.*

MACHINING THE HOLE FOR THE PUNCH AND FINISHING A BLANKING DIE.

In the September issue of MACHINERY, the way in which a common blanking die is planed and laid out was described. After the die has been laid out accurately the next step is to machine the hole for the blanking punch. The way in which this is done will depend somewhat upon the shape of the blank which is to be produced. As the hole through the die which we have selected as an example and which is shown on Shop Operation Sheet No. 76, has circular ends, the lathe can be used to advantage for machining these ends. A plan of the die blank after being laid out, is shown, and also a view of the blank strapped to the lathe face-plate.

First, one hole is drilled and bored to the required radius for the ends, then the blank is shifted on the face-plate and the operation repeated. In order to facilitate setting the work accurately, an indicator *M* is used. This is attached to the tool-post, and its end inserted in the center punch mark located in the center of the hole to be drilled and bored. As the work is revolved, any circular movement of the center punch mark will cause the end *G* of the indicator to move in a much larger circle. By keeping the tail-stock center close to the end *G*, the result of each attempt to shift the work on the face-plate and locate it in its correct position, will be plainly visible. When the center punch mark coincides with the axis of the lathe spindle, the end of the indicater will remain stationary.

The next step is to remove the core. This can usually be done most conveniently by drilling a row of holes just inside the line representing the outline of the master templet. If each alternate hole is first drilled and then the remaining ones, the holes can be spaced closer and drilled with less difficulty, and there will be no bridges between adjacent holes to hold the core in place. It is necessary that a die have clearance, as shown in the sectional views, Figs. 1 and 2, in order that the blanks, when sheared from the stock, may fall through the die; therefore, when drilling, if a thin strip is inserted beneath the blank and on the side farthest from the hole being drilled, so that the hole is inclined to the vertical equal to the clearance angle, considerable labor will be rendered unnecessary when finishing the die. The holes can also be drilled at right angles to the face of the die and then reamed out with a taper reamer, but the former method is more practicable.

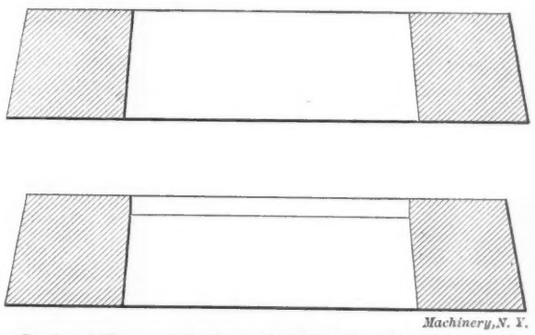
Most of the surplus metal can now be removed with a sharp chisel, but if the die is large it can be conveniently machined on the planer or shaper by strapping it to an angle plate which is inclined to the vertical sufficiently to give the die the proper amount of clearance. Of course, this work may be done more easily on a regular die-slottting machine, if one is available. If chipping is resorted to, the chisel should always be driven away from the top of the die as there is danger, when chipping from the other direction, of the metal breaking away outside of the lines. At times it may be advantageous to drill a single hole large enough to insert a milling cutter, and then work out the core on a vertical milling machine or a horizontal machine with a vertical attachment. A taper cutter can then be used for giving the die clearance.

The next step is to finish the hole to conform to the shape of the master templet. This is usually done by filing. A short piece of heavy wire should be fastened to the center of the blank, and perpendicular with it, as this will be convenient for handling the templet when fitting the die to it.

The die is fastened in a vise with its top or face toward the back of the vise. The hole is then filed to the line previously scribed on the die face. The templet should be frequently tried in the hole, the bearing points being marked with a pencil, and then removed with the file; this operation is repeated until the hole fits the templet perfectly and is large enough to allow it to just pass through. When testing the hole, the surface of the templet should be kept parallel with the top of the die. As the work is nearing completion it may be necessary to remove it from the vise each time the templet is inserted, to enable one to see the minute openings. A piece of white paper held on the opposite side of the blank will, however, suffice for the earlier stages of the work.

The amount of clearance ordinarily given a die is from 1 to 2 degrees. When the hole is being filed to size the clearance angle is made correct and uniform by testing the work with a die-makers' square, which differs from other squares in that the blade is set at an angle with the stock, of 90 degrees plus the clearance angle. In the sectional views shown in the engraving, two methods of giving clearance to dies are illustrated. In the one the clearance extends to the top of the die, while in the other there is a space of about ⅛ inch, which is practically straight, a very small amount of clearance being given. For very soft metals, such as soft, thin brass, the first method is preferable, but for harder materials such as hard brass, sheet steel, etc., it is better to have the clearance end a little below the cutting edge. With a die made in this way thousands of blanks can be cut without any great variation in their size, as grinding the face of the die will not enlarge the hole to any appreciable extent.

The clearance should be filed as straight as possible, so that the blanks, when cut, can fall through the opening easily. To file a narrow surface straight is difficult and requires considerable practice, and while one only becomes proficient in



Machinery, N. Y.

Sectional Views of Blanking Die Illustrating Two Methods of Giving Clearance.

work of this character through practice, still a hint as to the proper method of procedure may be useful. When the file begins its stroke, the downward pressure exerted by the left hand holding the outer end should be maximum, while a minimum pressure is given by the right hand; as the file advances, the pressure from one hand decreases while that from the other increases. After considerable practice, one is enabled, unconsciously, to regulate the pressures on each end of the file so that rocking is prevented. If the surface being filed becomes rounded this can usually be removed by using a sharp scraper which will cut the metal quite rapidly.

After the die is finished, the punch is laid out from it. If a die-makers' clamp, such as was illustrated in the Shop Operation Sheet accompanying the September issue, is available, it will be convenient for holding the punch against the die when laying it out. The amount of clearance between the punch and die is varied with the thickness of the stock; for thin material, as for example, tin, the punch should be a close sliding fit, but for heavy plate iron there should be a clearance equal to, at least, 1/16 the thickness of the stock. The pressure required to force the punch through the stock is less when there is clearance between the punch and die, but if this clearance be too great, a tapering hole will be the result. A slight taper is not, however, objectionable on some classes of work.

* * *

It is well known that brass becomes brittle at a temperature of about 550 to 900 degrees F. This is caused by the presence of lead or oxides of lead, or both. This brittleness, it is stated in the *Mining Journal* (London) can be prevented by mixing a certain amount of phosphorus with ordinary brass when heated above 550 degrees F. The proportion of phosphorus varies from 0.03 to 0.10 per cent. In some cases, when brass objects are subjected to high temperatures, and the metal generally does not give satisfactory service, phosphor brass gives excellent results, as for example, in the case of brass tubes for superheated steam.

* With Shop Operation Sheet Supplement.

LETTERS UPON PRACTICAL SUBJECTS.

Articles contributed to MACHINERY with the expectation of payment must be submitted exclusively.

WRITING CAM.

One of the manifold uses to which cam motion may be applied, is illustrated in the accompanying engraving of an arrangement called a writing cam. It consists of two cams of such outlines that a complete turn will make the pencil at the end of the upper follower *A* trace the letters U, W, make the short dashes in place of periods behind each letter, and return to the starting point. A closer inspection shows, that while the upper follower carrying the pencil, makes up and down movements, the lower one *B*, by means of a spring which keeps it in contact with the lower cam face, advances the paper at the proper rate in accordance with the movements of the pencil.

In designing the cams, the first step is to construct the chart shown in the lower right corner. For this purpose the letters or words are carefully drawn out and framed up as shown in the smaller rectangle, which is then divided into a sufficiently large number of equal parts, which are denoted by the letters of the alphabet, reading from right to left. To get the chart proper, a larger rectangle is drawn of any convenient length. The lower part of this figure is of the same height as the letters, and contains the curves of the upper cam *C*, while the height from the base to the top line is equal to the length of the smaller rectangle, as can be seen by the letters on the vertical line, and contains the curves for the lower cam.

The base line is next divided into an even number of equal parts, a multiple of four being preferable, because these lines represent as many radii, and the base circle has to be divided into the same number of parts. In the present case, 96 divisions were chosen as this permits of convenient subdivision. Having completed this step, the next is to evenly distribute or virtually stretch the letters over the lower part of the figure, leaving enough room for the home stroke, and then referring to the letters at the end of the rectangle, find the curve for the lower cam *D*. For instance, referring to the chart, while the pencil forms the straight line of the U which extends over radius 1-6, the paper does not move, therefore, that part of the curve for the lower cam is a horizontal straight line. The curved part of the same letter covers radius 6-14, and as the motion is uniform, the other curve drops uniformly to the intersection of radius 14 and a line drawn from between *ON*. The curve then stays at this height for the other straight part of the U to radius 20, then drops from *N* to *M* and radius 22, for the break between the two letters. In forming the W, the curve drops successively from *M* 22, to *J* 34, to *G* 46, to *D* 58, to *A* 70, each of these drops corresponding to one straight part of the letter W.

If the uniform law of motion had been followed, the curves would have been straight lines for the straight parts of the letters. In the present case this would, however, result in sharp corners at the joints of the W, which again would result into abrupt changes in the cam outline. To avoid this, the harmonic law of motion has been used, which insures continuous and smcoth curves and cam outlines. The lines from 70 to 96 are for the return stroke, and being of minor importance no special law of motion has been employed.

To lay out the cams, the base circle and the large circle which passes through the fulcrum of the upper lever follower, are drawn and divided into the same number of equal parts as the chart. In numbering these radii, care must be taken in locating the zero point for each cam, which lies at the respective point of contact of cam and follower. Going out from the base circle, the distances of the chart are stepped off on the corresponding radii. As, however, the upper follower moves in circular arcs, it is evident that the distances must be laid off on arcs drawn from the various division points of the fulcrum circle with a radius equal to the lengths of the follower from fulcrum to point of contact. Connecting then the various points so found by a continuous line, the theoretical cam curve is obtained.

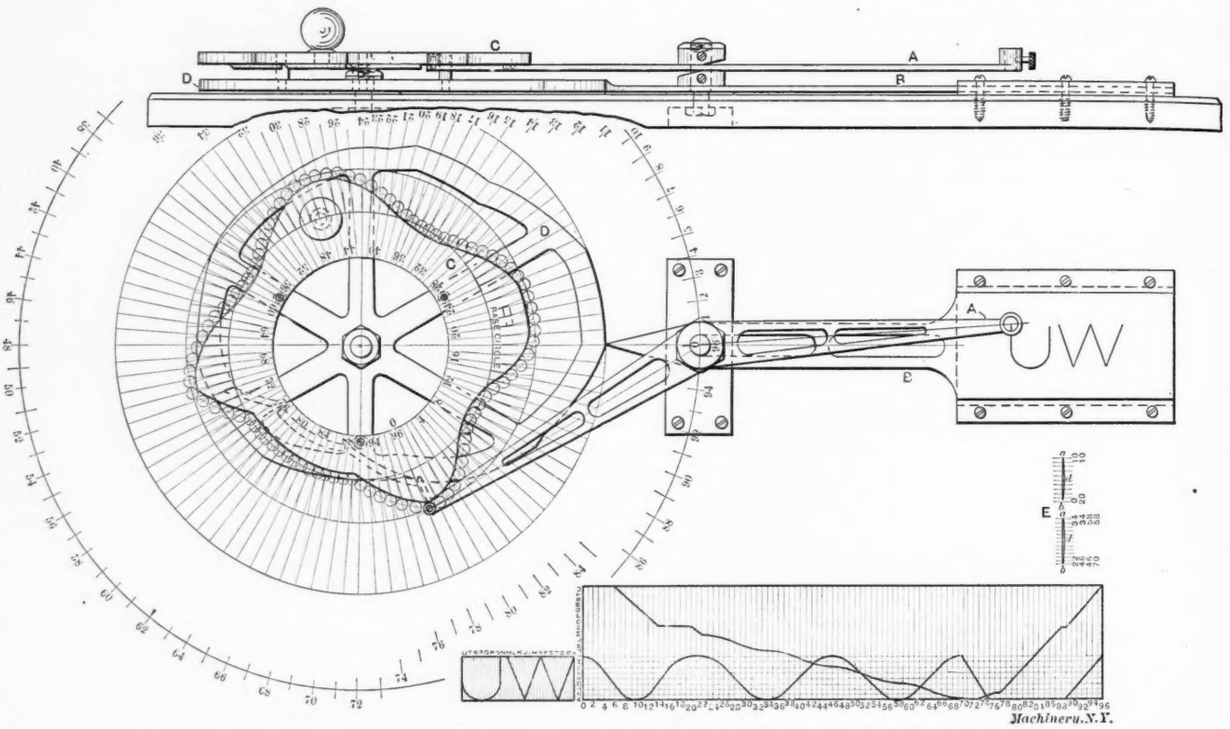


Fig. 1. Method of Laying Out the Curves for the Two Cams which Control the Movements of the Pencil and Paper.

Fig. 2. The Letters as they would appear, owing to the Circular Movement of the Pencil, if the Cam controlling the Movement of the Paper were not corrected to prevent it.

If roller followers are used, the working curve is found by the usual process of reducing the contour an amount equal to the radius of the roller. In this case this applies to the upper cam only.

The working curve of the lower cam is identical with the theoretical, except for a correction due to the circular movement of the pencil, which would give the letters a distorted appearance, as shown in Fig. 2. It is therefore evident that,

if a straight line is to be drawn, the paper must be moved back and forth just enough to take up the arc formed by the pencil. The way to find the proper distance to be added is shown at *E*, where *a-b* is the height of the letters and arc *a-d-b* the path of the pencil. The divisions are the numbers of the radii over which the part of the letter extends. The chart shows that each stroke of the U, covers 10 radii, from 0 to 10 and 10 to 20, while the W requires 12 for each stroke, from 22 to 34, from 34 to 46, from 46 to 58 and from 58 to 70. Two constructions are therefore necessary. Adding now the distance between line *a-b* and arc *a-d-b* to the corresponding radius to the previously found curve, the rectified working outline of the cam is obtained.

To produce the break between the letters, a little metal strip at the bottom of the upper cam, presses the upper follower down at the proper moment and thus lifts the pencil off the paper. The same principle is applied for the return stroke. As soon as the last part of the W is formed, at radius 70, as the chart shows, the pencil is lifted and goes to the bottom line from radius 70 to 75. At radius 75 the metal strip is interrupted and the pencil drops down and forms the dash behind the W from radius 75 to 76, where the lower cam dwells from 76 to 77 to give the pencil time to rise and thus insure a sharp line to the finish. The same process is repeated for the dash behind the U, where the dwell extends from 88 to 89.

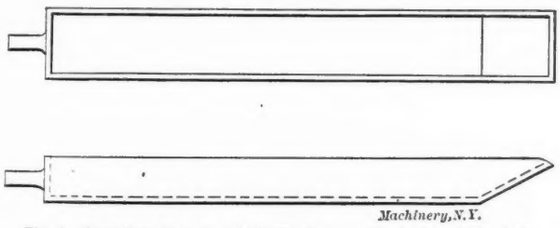
As a suggestion, it might be said that it is advantageous to use a fairly large construction and also to avoid letters where straight lines appear, as far as possible, as this would facilitate the work considerably by permitting the use of uniform motion curves throughout and thus doing away with the correction mentioned before. This correction might also be avoided by the introduction of some mechanical device for converting the arc formed by the pencil into a straight line, as for instance Watts straight line motion, or other contrivances.

A. E. SCHULZ.

Chicago, Ill.

TO HARDEN HACK-SAW BLADES IN QUANTITIES.

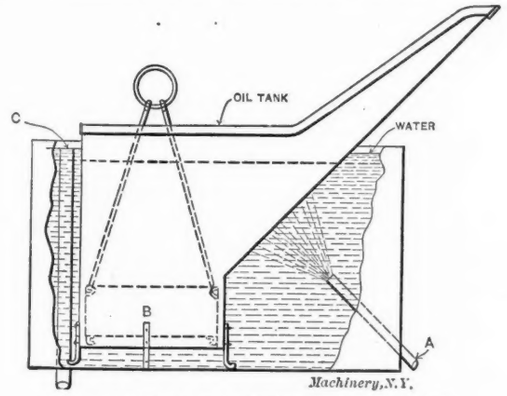
In the How and Why page of the August issue, H. G. asks for information concerning the way in which hack-saw blades are hardened in large quantities. Blades may be hard-



Machinery, N.Y.

Fig. 1. Cast Iron Box in which Blades are Packed and Heated.

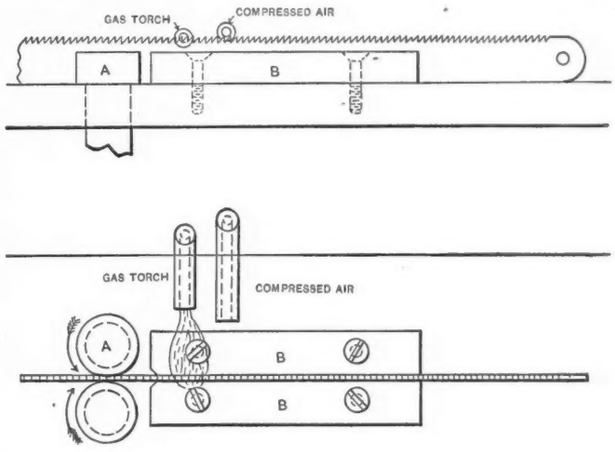
ened in quantities by using cast iron boxes of the style shown in Fig. 1, in which to heat them. The boxes should be large enough to accommodate about three dozen blades placed on



Machinery, N.Y.

Fig. 2. Oil Tank for Hardening Hack-saw Blades.

edge with the back down. A little charcoal should be used at the sides to keep the teeth of the outside blades from coming in contact with the sides of the box. The blades are then placed in the muffle of a furnace and allowed to remain until they have reached the proper temperature for hardening. They can then be removed with a pair of tongs made to fit the shanks on the ends of the boxes. The blades should then be carefully dumped on the inclined chute of a linseed oil bath which is shown in Fig. 2. The tank containing the oil is placed inside a wooden tank which is filled with water which keeps the oil from getting overheated. Water is sup-



Machinery, N.Y.

Fig. 3. Method of Hardening Flexible Hack-saw Blades.

plied through pipe *A*, and strikes directly on the lower side of the chute down which the blades slide on their way to the bottom where they collect in a wire or perforated sheet metal basket *B*. An overflow pipe *C* is placed at one end of the water tank to carry off the warm water which rises to the top. The oil tank should rest upon legs several inches long, so as to raise it above the bottom of water tank to allow a free circulation of the water. When the blades are fairly cooled off, the basket containing them can be removed from the oil and allowed to drip over the tank until most of the oil has left the blades; they can then be thoroughly cleaned by being immersed in a soda kettle or by placing them in clean sawdust. Flexible blades are treated differently, they being hardened on the teeth only. A fixture of the style shown in Fig. 3 is used for this method of hardening. The blades are placed, back down, between two power-driven rolls *A* which rotate in different directions, and which feed the blades, by friction, between two guides *B* and past the flame from a gas torch which heats the teeth sufficiently for hardening. A compressed air jet strikes the hot teeth immediately after they pass the torch. The temper does not have to be drawn on blades hardened by either process, except at the ends, which is usually done with a torch.

Plainfield, N. J. JAMES CRAN.

RACK CUTTING ON THE SHAPER.

We recently had occasion to cut a rack for a mandrel press which was in process of construction in our shops for our own use. As we desired to complete the machine with the facilities at hand, it was somewhat of a question as to what method would be used for spacing the teeth of the rack, which was to be cut in the shaper, a Lodge & Davis machine about twenty years old but still in good repair. The first suggestion was to clamp a finished rack, of the same pitch, in the vise with the rack to be cut, and set the tool for each cut by see-sawing the table back and forth until the tool dropped easily into the finished rack, which would give the proper spacing. The plan was abandoned for several reasons, among which was the fact that we did not have an 8-pitch finished rack to use in this way. Furthermore, the rack was to be cut in a round piece, about three inches in diameter, which had been shaped down flat for a part of its length, as shown in Fig. 1. In addition to this, its shape rendered clamping a finished rack with it somewhat difficult, and as the piece was in position to cut the teeth after shaping, it would have to be reset. The following plan was then adopted:

The diametral pitch of the rack being 8, its circular pitch is $\frac{\pi}{8} = 0.3927$ inch, and this is the amount the table has to be moved for each cut. The number of threads per inch of feed-screw was found to be 4; therefore its pitch is ¼ inch = 0.25

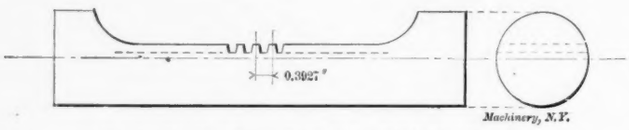


Fig. 1. Mandrel Press Rack to be Cut in the Shaper.

inch, or for one turn of the feed-screw the table is moved 0.25 inch. To move the table a distance equal to the pitch will require $\frac{0.3927}{0.25} = 1.5708$ turns of the feed-screw. The decimal part of this number, or 0.5708 is almost equal to 4/7, so that 1 4/7 turns of the feed-screw moves the table a distance equal to 1 4/7 × 0.25 inch = 0.3927 inch, approximately, which is the proper spacing.

In the practical operation of this scheme, in order to get the fractional part of a turn desired, the index plate and

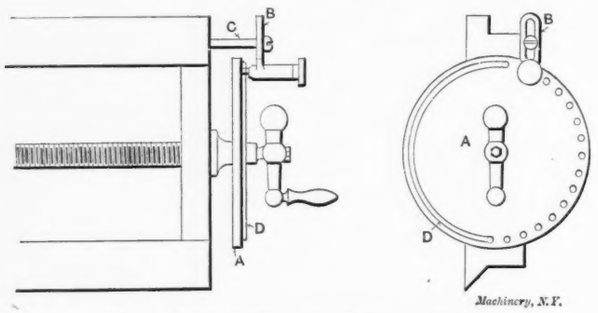


Fig. 2. The Index Plate attached to the Shaper.

worm-crank from the milling machine were brought into use and placed as shown in Fig. 2. The pawl and ratchet feed of the shaper were removed, and the index plate *A*, with a 49-hole circle, was clamped in its place, a shouldered bushing being used to make the fit and keep the index plate concentric with the feed-screw. The worm-crank *B* was then fastened to the rod *C* with a screw, and this rod clamped to the saddle by a

TABLE GIVING NUMBER OF TURNS OF FEED-SCREW FOR INDEXING A GIVEN PITCH.

Pitch of Rack.		Pitch of Thread on Feed-screw.									
		⅓″		¼″		½″		⅛″		¼″	
Diametral.	Circular.	Turns.	Error.	Turns.	Error.	Turns.	Error.	Turns.	Error.	Turns.	Error
3	1.0472	$3\frac{7}{49}$	+4	$4\frac{7}{37}$	+1	$5\frac{4}{17}$	−2	$6\frac{11}{39}$	−2	$8\frac{14}{37}$	+1
4	0.7854	$2\frac{11}{21}$	−4	$3\frac{7}{15}$	+3	$3\frac{18}{41}$	0	$4\frac{35}{49}$	+3	$6\frac{11}{39}$	−1
5	0.6283	$1\frac{38}{48}$	−4	$2\frac{20}{39}$	−1	$3\frac{7}{49}$	+3	$3\frac{30}{39}$	−1	$5\frac{1}{37}$	+1
6	0.5236	$1\frac{28}{49}$	+2	$2\frac{2}{21}$	+2	$2\frac{29}{47}$	−2	$3\frac{7}{49}$	+2	$4\frac{7}{37}$	0
7	0.4488	$1\frac{17}{49}$	+3	$1\frac{31}{39}$	−1	$2\frac{10}{41}$	0	$2\frac{37}{49}$	−1	$3\frac{23}{39}$	−1
8	0.3927	$1\frac{7}{39}$	+5	$1\frac{28}{49}$	+2	$1\frac{36}{37}$	−1	$2\frac{11}{21}$	−2	$3\frac{7}{49}$	+1
9	0.3491	$1\frac{1}{21}$	+1	$1\frac{17}{43}$	−3	$1\frac{36}{47}$	−2	$2\frac{2}{21}$	+1	$2\frac{23}{39}$	0
10	0.3142	$\frac{16}{17}$	−5	$1\frac{10}{39}$	−1	$1\frac{28}{49}$	+1	$1\frac{38}{45}$	−2	$2\frac{19}{37}$	0
11	0.2856	$\frac{47}{49}$	+1	$1\frac{7}{15}$	+1	$1\frac{15}{41}$	+1	$1\frac{35}{49}$	+1	$2\frac{14}{49}$	+1
12	0.2618	$\frac{39}{47}$	−5	$1\frac{1}{21}$	+1	$1\frac{12}{39}$	−3	$1\frac{28}{49}$	+1	$2\frac{2}{21}$	+1
14	0.2244	$\frac{33}{49}$	+1	$\frac{44}{49}$	+1	$1\frac{5}{41}$	0	$1\frac{17}{49}$	+1	$1\frac{31}{39}$	0
16	0.1964	$\frac{28}{49}$	+2	$\frac{37}{47}$	+4	$\frac{48}{49}$	−5	$1\frac{7}{39}$	+2	$1\frac{28}{49}$	0
18	0.1745	$\frac{11}{21}$	+1	$\frac{30}{43}$	−1	$\frac{41}{47}$	0	$1\frac{1}{21}$	+1	$1\frac{17}{48}$	−1
20	0.1571	$\frac{8}{17}$	−2	$\frac{37}{43}$	−1	$\frac{37}{47}$	+3	$\frac{16}{17}$	−2	$1\frac{10}{39}$	0

thumb-screw, not shown. The fraction 4/7 = 28/49, and for spacing the 28 holes, a piece of wire *D*, of a proper diameter to fit loosely in the holes of the index plate, was bent at the ends to such a length as to span 26 spaces on the 49-hole circle, leaving the other two holes of the 28 open to receive the pin of the worm-crank, one hole at each end of the wire. The work was then spaced just as the teeth are spaced in the milling machine, and was found accurate. When the feed-screw shaft is too large for the hole in the index plate, the latter may be mounted on the back end of the screw where the nut is placed to take up lost motion.

As the method has a wide application for spacing equal divisions, the accompanying table was prepared to apply to racks up to 20 diametral pitch, and for a number of different pitches of feed-screw.

Thus, to space a 9-pitch rack on a shaper having a feed-screw with 6 threads per inch, we find from the table that it requires 2 2/21 turns, which will be accomplished with the index plate having a 21-hole circle, taking two full turns + 2 holes on the 21-hole circle. The errors tabulated in the table are in ten-thousandths of an inch for each space, the sign showing whether the space thus given is too great or too small. Thus, an error −1 shows each space to be 0.0001 inch too short. The total error in a rack of 100 teeth would then be but 1/100 inch, which is negligible for most work. However, the errors are all tabulated, that none may fall into error by using the approximations here given. If it is desired to use this method to cut a rack to work with a gear, the pitch of which is given in *circular* measure, the spacing may be done as follows. Suppose the pitch of pinion to be 13/16 inch, and the feed-screw has 5 threads per inch: 13/16 inch = 0.8125 inch, and one turn of the screw moves the table 1/5 inch = 0.2 inch. The turns required are therefore $\frac{0.8125}{0.2} = 4.0625$ = 4 1/16 turns, which will be made by using the circle with 16 holes.

W. L. Benitz.

Notre Dame, Ind.

GRAPHICAL DETERMINATION OF THE CROSS-ROLL CURVE.

In the December, 1907, issue of Machinery was given a mathematical derivation of the cross-roll curve. In the July, 1908, issue was given a graphical method which, however,

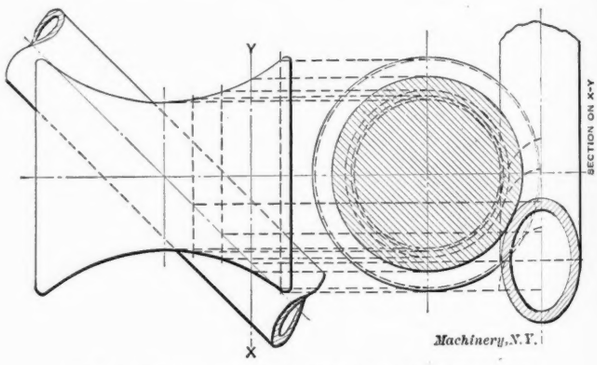


Fig. 1. Graphical Method of Laying Out Cross-roll Curve.

seems rather awkward and cumbersome. The following graphical methods will be found far more convenient. Lay out in two views the axis of the cross roll and the center line of the pipe, as shown in Fig. 1. Intersect both projections by sev-

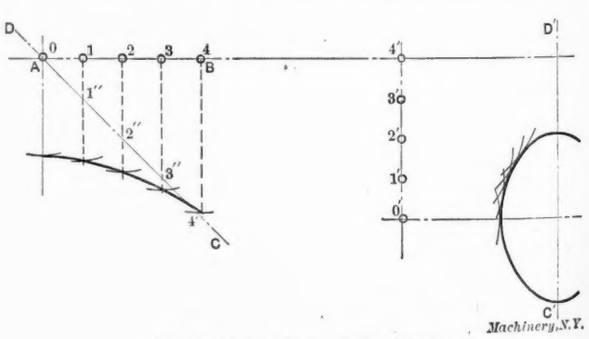


Fig. 2. Method in Fig. 1 Simplified.

eral parallel planes, all perpendicular to the axis of the roll. The sections of the pipe will all be ellipses; the corresponding sections of the roll must be circles tangent to these ellipses. The radii of these circles may be set off from the axis of the cross-roll in their respective planes, and the form of the cross-roll curve thereby determined.

The amount of work required for this construction may be reduced, and the accuracy of the construction increased, by arranging the sections so that all the sections of the pipe coincide, noting, of course, the corresponding change in position of the axis of the roll in each case. Such a construction is shown in Fig. 2. When this method is used the ellipse need be drawn but once. The line *AB* represents the axis of the cross-roll, and the line *CD* the center line of the pipe. The ellipse is the section of the pipe intersected by a plane perpendicular to the axis of the roll at 4.

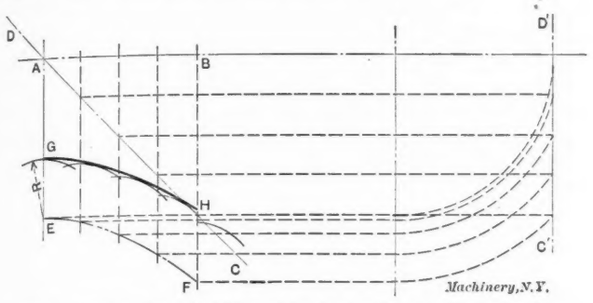


Fig. 3. Another Graphical Method for Laying Out the Cross-roll Curve.

Radii of arcs tangent to the ellipse having centers at 0′, 1′, 2′, 3′, and 4′ are laid off from 0, 1, 2, 3, 4 upon lines at right angles to *AB*. These radii determine the shape of the curve. The points 0′, 1′, 2′, 3′, 4′ are so located that the distance $0'1' = 1''1$, $0'2' = 2''2$, etc.

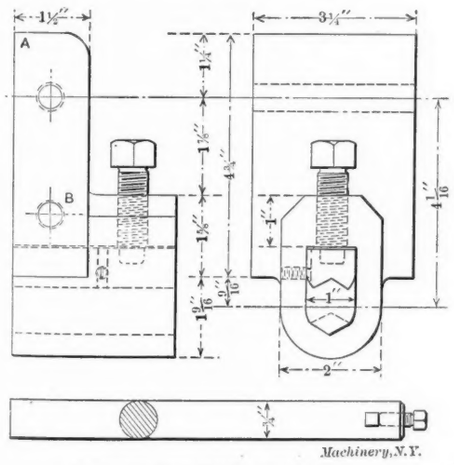
The construction shown in Fig. 3 is based on the fact that if the pipe were of zero diameter, the cross-roll would be in hyperboloid of revolution generated by the revolution of the center line *CD* about the axis *AB*. The curve *EF* for this hyperboloid is determined as shown. For a pipe of given diameter the form of the cross-roll is a curve parallel to the curve of this hyperboloid, and at a distance inside of it equal to the radius *R* of the pipe. The curve *GH* is therefore the required cross-roll curve.

E. H. Wood.

Ithaca, N. Y.

EXTENSION TOOL HOLDER.

The extension tool holder for the shaper, which is shown in the engraving, is extremely convenient and useful, and can be made at small cost. The one shown is for a 16-inch shaper, and will hold cutter bars from 1 inch down to ⅜ inch in diameter. The holder is fitted into the clapper box, and takes



Extension Tool Holder for the Shaper.

the place of the clapper. When putting it in, it is necessary to drive out the taper pin and remove the clapper, then when the holder is in place and the pin driven in again, the upper square corner at *A* prevents its turning and makes a solid fixture of it. The opening for holding the cutter bar is low enough so that the bar can be extended backward under the tool head, which enables the length of the working part of the bar to be changed to any length desired. With this arrangement there is no "blocking down" of the tool, no toolpost to interfere, and the bar can be rotated so as to bring the cutter into any position. I have found it to be an advantage in doing work with an extension tool of this kind, to reverse the position of the cutter, so that it will take a draw cut. If used in this way, there should be an additional taper pin put through in some such position as *B*, so as to make it more rigid for the draw cut. As the ordinary shaper head is not very strong for draw cutting, great care must be exercised when using it this way. The tool cuts smoother, however, and is not nearly so likely to "hog in"; the lines on the work are in front, and it is altogether a more satisfactory way to work.

W. A. Knight.

Columbus, O.

GAS ENGINE VALVES.

The accompanying engravings illustrate the method used by one of the most progressive automobile concerns in the East, of making gas engine valves. The stock is first taken in bar form and blocked down under a trip hammer; then it is reheated and finished, as shown in Fig. 1, with one heat

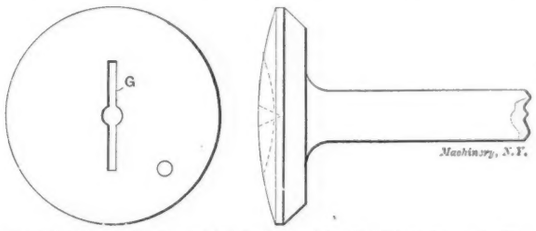


Fig. 1. Gas Engine Valve which is formed by the Dies shown in Fig. 2.

between dies *A* and *B*, Fig. 2. These dies produce a finished head and stem, to forging dimensions, also a screw-driver slot and center impression. *A* is the body of the top die; *C* is the inserted center die which contains the centering plug *F* and blades *E*, and the screw *D* which forms a backing

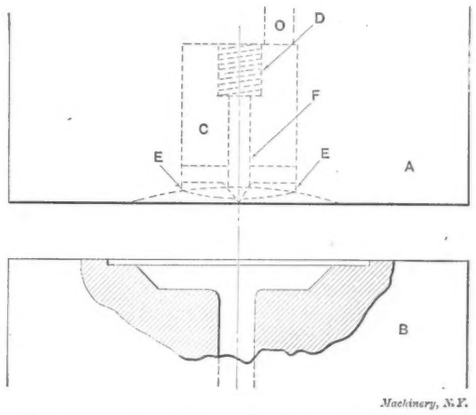


Fig. 2. The Upper and Lower Dies for Forming the Valve Head and Stem.

for the plug *F;* hole *O* in *A* is to facilitate easy removal of *C* for renewal of center plug *F* and blades *E*. These blades form the screw-driver slot *G* in the valve head, as shown in Fig. 1. The dies were designed with the idea of doing away with two operations; milling the screw-driver slot, and center

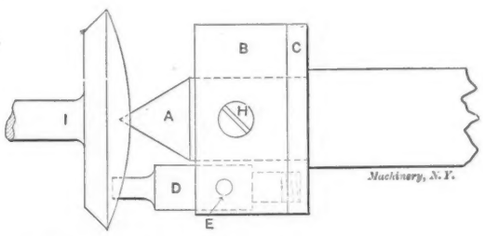


Fig. 3. Method of Driving the Valve when Turning.

punching the head end of the valve, also for making it an easy matter to center the head end for turning in the lathe. The slot is used to drive or rotate the valve when grinding in the seat after cylinder and valve have been machined.

In Fig. 3 is shown the driving head for turning. *A* is the center which fits the lathe spindle and *B* and *C* are two rings or collars which are an easy fit on the straight portion of *A*.

D is the driver which fits into a part round and part elongated hole in *B*, and is kept in place by pin *E*. The large diameter of *D* is a little smaller than the elongated hole in *B*, so that it will have a radial motion to allow for any variation between the center and the driving hole in the valve. There is some variation in the distances of these holes owing to the oval surface of the valve which causes the drill to crawl

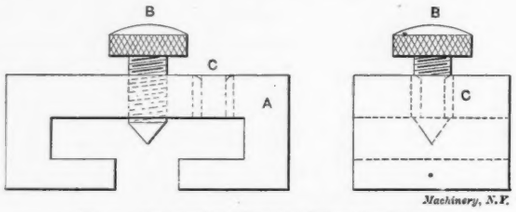


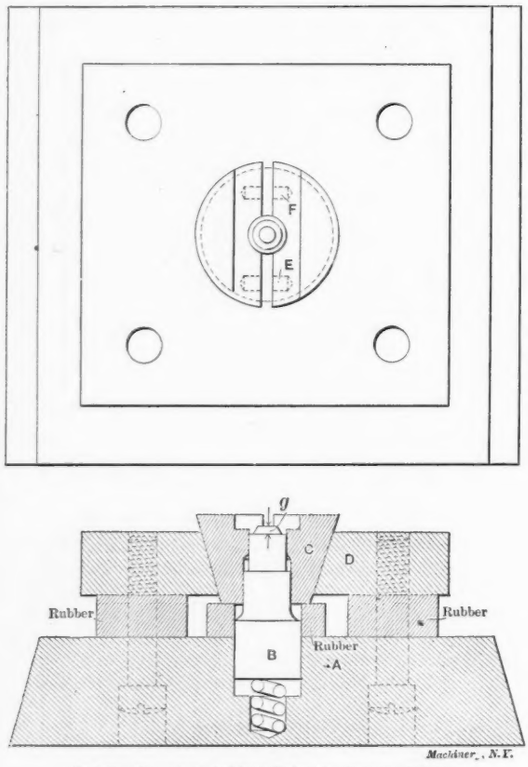
Fig 4. Jig used for Drilling Holes for Driver.

a little. The screw *H* holds the rig firmly in place, a flat being milled on *A* which it seats against. In Fig. 4 are shown elevations of the jig used for drilling the driving hole. *A* is the body of jig, *C* the bushed drill hole, and *B* the clamping screw with a 60 degree point which locates and clamps the valve in position while the drive hole is being drilled.

E. S. WHEELER.

DIE FOR COUNTER-SINKING HOLES IN CORNER IRONS.

In the engraving is shown a die used for counter-sinking holes, previously pierced, in corner irons of five different sizes: ⅝, ¾, ⅞, 1, and 1⅛ inch inside, and 3/32 and ⅛ inch thickness. The work is done by this device much quicker than it can be done in a drill press. The work is placed in the groove in the part *C*, shown in the sectional view, and the plunger *B*, which has a sliding fit in the base-plate *A*,



Die for Counter-sinking Holes in Corner Irons.

counter-sinks the metal around the holes in the work, by being pressed into it. The bevel on the point of this plunger *B* is made the same as the angle of the screw-head to be used for the corner irons, but the distance *g* is somewhat less than the thickness of the stock, so that the point will not project through the stock and strike the punch. The punch used is simply a flat-bottomed plunger, 2 inches square, having a perfectly smooth bottom surface, and hardened.

The sleeve *C* is made in five different sizes, one for each size of corner iron, and is turned tapered on the outside to fit into the holder *D*. The sleeve *C* is split, and after being split is drawn to a purple and hardened. There are two holes in each of the halves of the sleeve *C*, at *E* and *F*, as shown in the plan view. These holes contain springs which hold the two parts of the sleeve apart, so as to admit the stock. When the stock is placed in the groove in sleeve *C*, it is located by the point of the counter-sink *B*, and, as the punch descends, it first forces the sleeve *C* into the holder *D*, thus clamping the stock and preventing it from bending. The annular rings, shown under both *D* and *C*, are rubber pads, permitting a springing action, as soon as the stock is firmly held in sleeve *C*.

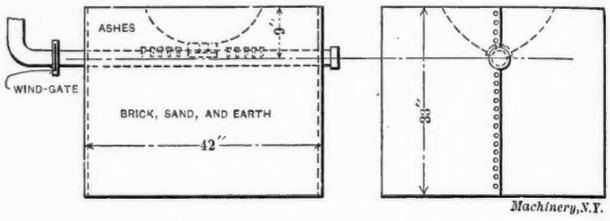
The spring under the plunger *B* holds it up against the work, and makes it possible for the point to locate the hole in the work before the punch has descended far enough to force it into the work, forming a counter-sunk hole. Plunger *B* should be left as hard as possible, because it is subject to considerable wear.

S. S. HART.

Aurora, Ill.

A CHEAP HOME-MADE FORGE.

To make a cheap forge, a cylinder is first made about 3 feet 6 inches in diameter and about 2 feet 9 inches high, from ⅛-inch sheet steel, as shown in the engraving. Then two holes are cut in this cylinder opposite each other about 9 inches from the top edge. These holes should be large enough to allow a 2½ or 3-inch common steam pipe to pass through freely. For a forge intended for heavy forging, a



Serviceable and Inexpensive Forge.

3-inch pipe is to be preferred. The pipe should be long enough to pass through the cylinder and extend about 2 inches outside on one side, and 6 or 8 inches on the other side of the cylinder. The end of the pipe that extends out about 2 inches should be threaded, and a cap should be screwed on this end in such a way that it can be removed or put on by hand. A wind gate is now put on the other end of the pipe, and this is then attached to the blast pipe. After having laid the pipe in place temporarily, a 1¾-inch hole is drilled into the pipe on one side, and on each side of this hole three ¾-inch holes, followed by two ⅝-inch holes, about 3 inches apart, are drilled. A piece of steel, one inch thick, about 4 or 5 inches wide, and long enough so that it will go at least one-third around the pipe, is now made. In the center of this piece a 1¾-inch hole is drilled, and the piece is bent so that it will fit the outside of the pipe. This piece is placed directly over the 1¾-inch hole in the pipe, being attached with some fire clay. It serves the purpose of prolonging the life of the pipe, and keeps the pipe from burning out at the hole. After the forge constructed in this manner is leveled up, broken brick, sand, dirt and cinders are dumped in and packed firmly up to the lower side of the pipe. One-half inch bolts or rivets, about 1½ inch long, are put in the small holes, and then the remaining part of the cylinder is filled up with cinders and packed firmly, space being left to form a pit for the fire. The forge is now ready for use.

The advantages of this forge are: It is possible to make a large or small fire, according to the requirements; if a long fire is required one can pick out enough of the cinders and take out the bolts or rivets mentioned; the length of the fire can be adjusted to the requirements by taking out more or less bolts; there is no brick or fire clay lining to be set before the forge can be used. The writer has built several of these forges in various shops, and they give the best of satisfaction. The forge will work well until the pipe rusts

out, and then another pipe is made and put in place at very small expense, and very little loss of time.

When the fire gets dirty, use the poker and poke the dirt down through the hole. Take off the cap at the end of the pipe and open the wind gate and blow out the cinders inside of the pipe. It takes no more than two minutes to clean a fire in one of these forges. The writer prefers this forge to any other as the most serviceable and inexpensive one to use on any class of work. It is adapted to a great variety of forging. The writer has made big blanking dies, welded 8-inch diameter shafts, and put ¼-inch links in chains, on the same forge.

GEO. T. COLES.

Decatur, Ill.

ON OBTAINING APPROXIMATE FRACTIONS.

Referring to the article contributed by me on the subject "How to Obtain Approximate Fractions by the Method of Continued Fractions," which was published in the August issue of MACHINERY, I would say that before trying to obtain the approximate fractions of a fraction, one should first attempt to factor said fraction. In the selection of 729/1,000, as shown in the article, it was resolved into approximate fractions to serve as an illustration of how the work was done, yet it might have been factored thus: $729/1{,}000 = 81/100 \times 9/10$. Retaining the 81/100 and raising the 9/10, for instance, to 36/40, we should then have 81/100 and 36/40 as fractions indicating gears that might be used, and which would give the required lead exactly.

Providence, R. I. MITCHELL DAWES.

SPECIAL BORING-BAR.

A special boring-bar for use in either lathes or horizontal boring mills is illustrated in Fig. 1. This bar is adapted for boring taper holes or cutting grooves in bearings, as well as for other classes of work that it is profitable to do with a single-ended cutter. The bar is made of ordinary machine steel, and has a taper shank to suit the spindle of the boring mill. Length *A* is made twice the length of the hole that is to be bored and

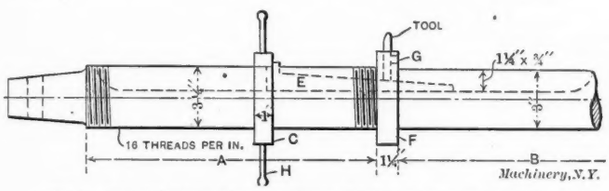


Fig. 1. Special Boring-bar for Taper Boring or Groove Cutting.

is chased 16 threads per inch the full length. Collar *C* is made of machine steel, threaded to suit bar, and case-hardened so as not to allow it to cut where it comes into contact with the steel bevel key *E*. This key is case-hardened, and is made the exact bevel of half the difference of the diameters of the two ends of the taper hole to be bored, and is a sliding fit in

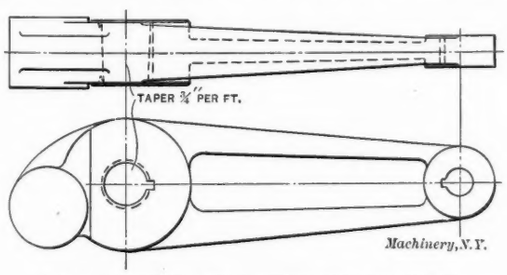


Fig. 2. Example of Taper Boring done with the Bar.

a ¾-inch keyway. The key should be not less than 1 inch longer than the length of the hole which is to be bored, so as to allow for starting the ½-inch square tool, which is held in collar *F* by a slotted set-screw *G*. The tool is a sliding fit in a square hole in the collar and the collar is shrunk on the bar.

In operating the bar, the boring mill is geared to cut 16 threads per inch, and the tool set to the amount of cut desired to be taken. A parallel strip is then clamped to the table, upon which one of the four handles *H* is rested. When the machine is started, the threaded collar *C* is forced to travel on the bar, and as the bevel key *E* moves inward the tool is fed into the cut, the result being a taper hole the exact taper of the key. As long as the key is retained, the hole can be duplicated exactly, and there need be no fear of its not fitting the same as the original, which is very often the case. The feed of 16 to the inch would leave a rather rough finish, but this is easily overcome by using a broad-nose finishing tool.

When desiring to cut a groove, a tool is inserted in the collar *F* the exact shape of groove to be cut, and the bar is revolved in a stationary position. The collar *C* is then turned by the handles *H* so that the taper key forces the tool into the cut, and when the required depth is reached, set-screw *G* is

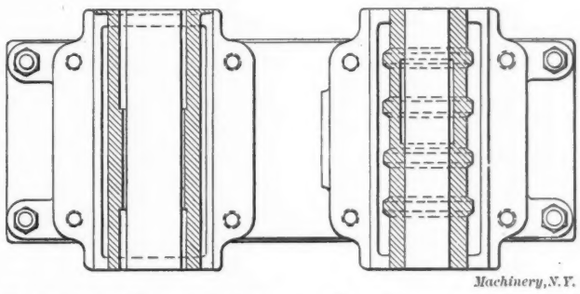


Fig. 3. Plan of Thrust Bearing showing Thrust Grooves cut by the Bar.

slacked off and the tool drops back into the slot; the bar can then be removed. The four handles *H*, which are tapped into the threaded collar *C*, give a momentum to the collar which facilitates removing the taper key *E* after each cut, thereby saving much time. It is only necessary to make the length *B* of the bar long enough to reach the yoke of the boring mill. On the lathe, the bar is used practically the same as on the boring mill with the exception that the work moves instead of the bar. The bar is especially adapted to performing work on castings too large to swing in the lathe or vertical mill. It proved to be very economical for finishing twelve cast steel levers similar to the one shown in Fig. 2, which were too long for any lathe or vertical boring mill to swing, in the shop where the bar was made. Fig. 3 shows a plan of a large thrust bearing which has thrust grooves. The bar was very useful in cutting these grooves, which were required to have a fine finish and be very accurate. This would have been a very difficult job to do with the ordinary boring-bar. This bar can be put to various other uses, and, owing to its simple construction, is quite inexpensive. It can, of course, be made in various sizes to suit very small as well as large work.

R. S. F.

AN ADVANTAGE OF IGNORANCE.

A variation of Billy's experience related in the May issue may be worth while telling. A farmer who needed a few repairs done on some of his implements, requested a local repair man to permit him to use a drill press, himself, in order to save time on his own work. Permission being granted, some smart Jimmy, as usual, crossed the belt, but the farmer, not being as nearsighted as poor old Bill, promptly reground the drill to suit the drill press. Needless to mention, the Jimmy figuring in this case was dumbfounded, and attended unusually well to his own business for the balance of the day, excepting, of course, that he spent some time trying to find out "how it was done."

ALFRED N. HAMMOND.

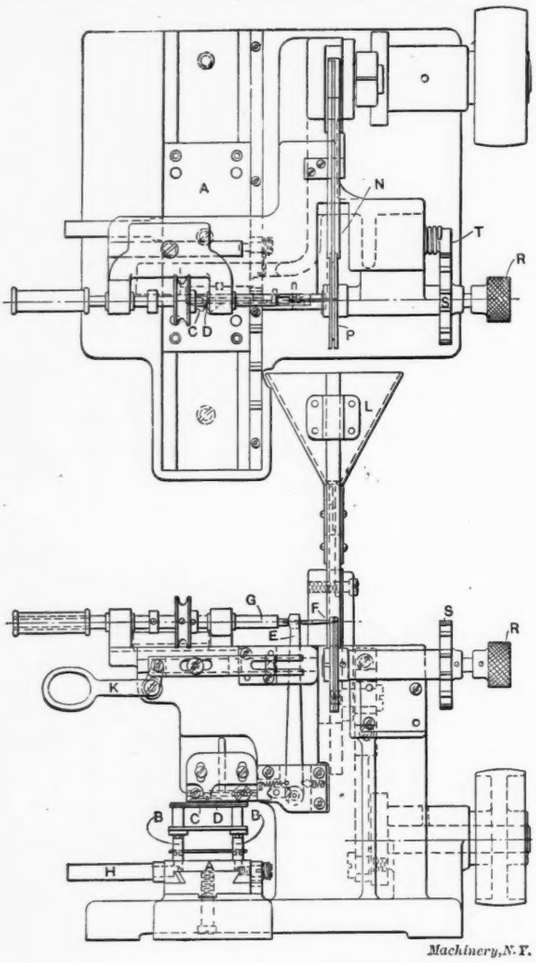
Erie, Pa.

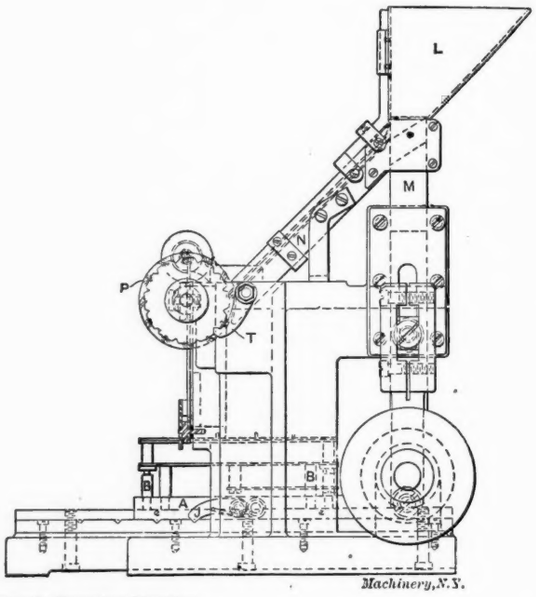
SEMI-AUTOMATIC REAMING MACHINE.

The accompanying illustration represents a small bench machine, designed for reaming holes in the pointers used on an electric meter. These holes are tapered 0.01 inch per inch, and are forced onto taper shafts after the latter are assembled in the register. The taper shafts vary in diameter so that it is necessary to ream each pointer to fit the shaft on which it is to be used. The usual method of fitting these is to use, when assembling, a hand reamer with which the pointers are reamed until they fit the shaft at the proper dis-

tance from the end. This method requires a great deal of reaming and fitting, and thus is not very satisfactory where a large production is required.

It will be observed that the device here illustrated is fitted with a slide *A* on which pins *B* are provided to hold the register, after the latter has been assembled with the pointer shafts and is ready to be fitted with the pointers. Directly above slide *A*, and in line with the pointer shafts, are located two gage points *C* and *D*, one fixed, and one movable, the latter operating a lever or indicator *E* on the same principle as a multiple gage. The upper end of the indicator *E* is split, forming a fork which straddles the taper reamer *F* thus forming a stop for spindle *G* as shown in the front elevation. Slide *A*, which carries the register, is operated by handle *H*, and the pointer shafts are stopped in alignment with the gage points by means of a pawl *J* which engages with the four notches as shown. Spindle *G* slides in its bearings, and is driven by a small grooved pulley. The back end of the spindle is provided with a spool by means of which the spindle is operated back and forth. Lever *K* operates a friction clamp, which in turn locks the indicator *E*, thus forming a positive stop for the spindle. It will be noticed that this machine is provided with a magazine feed, by means of which the pointers are automatically carried in position to be reamed. The method of accomplishing this will be readily seen. Hopper *L* forms a receptacle for the pointers. Plunger *M*, which is operated up and down through the center of the hopper, is slotted in the end so as to pick up the pointers and carry them down in the proper position to drop into the magazine *N*, from which they are conveyed to the revolving chuck *P*. The magazine and chuck are so constructed as to prevent the work from entering in any but the right way. The chuck has twelve slots to receive the work, and is indexed by means of handle *R*. The index plate *S* is fastened to the same shaft as the chuck, and locates the work in alignment with the spindle by means of the pawl *T*. A small pulley drives a crank, which in turn operates the plunger *M*.





Elevations and Plan of the Semi-automatic Reaming Machine.

As before stated, the size of the reamed hole is governed directly by the size of the taper shaft, the idea being to remove the pointers from the chuck as fast as they are reamed, and place them on the shaft for which they were gaged. In setting up this machine for the operator, it is necessary to adjust the taper reamer to the proper depth. The register is first placed on the slide *A*, the latter is then brought forward until pawl *J* engages the first notch as shown in the side elevation, thus bringing the first pointer shaft between the gage points *C* and *D*. This operation causes the indicator *E* to assume a vertical position, which is not very important, although it should stand about vertical. The indicator is then locked by means of the lever *K* and friction clamp, as formerly described. It is then in position to stop the spindle. The reamer has a straight shank, and is held in the spindle *G* by a small set-screw by means of which it is adjusted to the proper length. The simplest way of doing this is to set the tool out gradually, trying the pointer on the shaft each time until it fits at the proper distance from the end. When it is set for one, the rest are bound to come right for the reason that the ratio of the indicator arms is such as to correspond with the taper per inch, which in this case is one-hundredth inch.

F. H. HALSTEAD.

Gt. Barrington, Mass.

THE EFFECT OF ROLLED BELTING ON ITS APPLICATION.

Perhaps the method adopted by the manufacturers, of rolling up leather belting, has been discussed in the columns of MACHINERY, but if it has not, we wish to call attention to a fault of the present practice. This fault has been forcibly brought to our attention lately while equipping our new machine shop. Obviously, belting should be rolled just opposite to the way it is now rolled if we are to apply the belting with the hair side next to the pulleys. It is the verdict of all good mechanics that belts wear best applied in this way, but belting is universally rolled with the smooth or hair side on the outside. This gives the belting a natural set or curve which is a great inducement to the mechanic to apply it to the pulley in the same way. Why do not the manufacturers roll belting the way it should go when in use?

G. R. LANG.

Meadville, Pa. G. R. Lang Co.

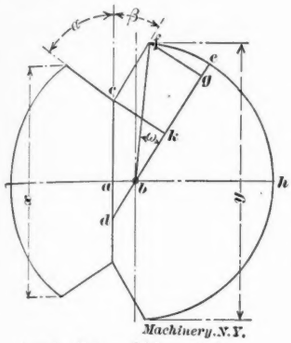
[The point made by our correspondent is important, and is one that should be taken into consideration by belting manufacturers, generally. Obviously a roll of belting looks best when made up with the smooth or hair side out, but as our correspondent says, the belting acquires a set when rolled in this direction that is hard to overcome when applied to pulleys with the hair side next to the pulleys, as it should be. Belting manufacturers who are desirous of having their belt-

ing applied so as to give the best results should give the matter their attention. Doubtless they will find that the mere matter of appearance is not nearly so important as convenience of application.—EDITOR.]

SIMPLE SOLUTION OF "A PROBLEM IN TRIGONOMETRY."

The following is a simple solution of "A Problem in Trigonometry," published in the How and Why section of the August issue of MACHINERY.

Let the given length $ac = A$; the given length $ab = B$; the given radius $= R$; and the given angles $= \alpha$ and β. Draw de parallel to cf, through the center of the circle; and ck and fg at right angles to de.



$$\text{Then } ad = \frac{B}{\tan \beta} \quad (1)$$

$$cd = ad + A = A + \frac{B}{\tan \beta} \quad (2)$$

$$fg = ck = cd \sin \beta = \sin \beta \left(A + \frac{B}{\tan \beta} \right) \quad (3)$$

$$\frac{fg}{R} = \sin \omega = \frac{\sin \beta}{R} \left(A + \frac{B}{\tan \beta} \right) \quad (4)$$

$$\text{Angle } fbh = 90^\circ - \beta + \omega \quad (5)$$

$$y = 2R \sin fbh \quad (6)$$

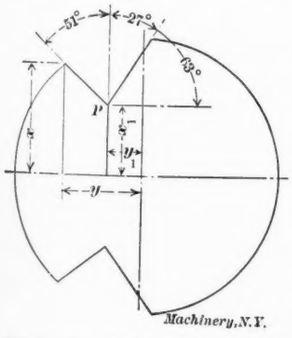
The length x is determined in the same manner. When the formula (4) has been obtained, this solution requires but three steps for finding the chord, although one step involves two divisions, one addition, and one multiplication.

Philadelphia, Pa. LOUIS J. SCHROEDER.

SOLVING "A PROBLEM IN TRIGONOMETRY" BY ANALYTICAL GEOMETRY.

The solution of S. S. Y.'s problem in the How and Why section of the August issue is an interesting practical exercise in trigonometry, but it may be solved more simply by analytical geometry. The object is to find the co-ordinates x and y of the points of intersection of the circle and the inclined lines passing through the point p.

The equation of a circle is $x^2 + y^2 = R^2$ if the origin of co-ordinates is at the center; and that of a line passing through a given point is $y - y_1 = a(x - x_1)$, in which $y_1 x_1$ are the coordinates of the given point, and a is the tangent of the angle the line makes with the axis of abscissas. Substituting known values in these equations, and combining them so as to eliminate y, we get the value of x, and *vice versa*. In the first of the two cases, the writer has changed the usual position of x and y, so as to get the angle 51° in the first quadrant, and thereby obtain a positive value of a.



The known values in the first case are: $R = 0.196$; $R^2 = 0.038416$; $x_1 = 0.1$; $y_1 = 0.03125$; $a = 1.2349$.

$y - 0.03125 = 1.2349 \quad (x - 0.1)$

$y = 1.2349x - 0.09224$

$y^2 = 1.525x^2 - 0.2278x + 0.00851$

$R^2 = 2.525x^2 - 0.2278x + 0.00851$

$2.525x^2 - 0.2278x = 0.0299$

$x^2 - 0.0902x = 0.01185$

$x = 0.0451 + 0.1178 = 0.1629$

$2x = 0.3258$

In the second case we put x and y in their usual position. We have given $a = tg\ 63^\circ = 1.9626$; $x_1 = -0.03125$; $y_1 = 0.1$.

$y - 0.1 = 1.9626 \quad (x + 0.03125)$

$y = 1.9626x + 0.1613$

$x = 0.5094y - 0.0822$

$x^2 = 0.2595y^2 - 0.0837y + 0.0067$

$R^2 = 1.2595y^2 - 0.0837y + 0.0067$

$y^2 - 0.0665y = 0.0251$

$y = 0.19525$

$2y = 0.3905$

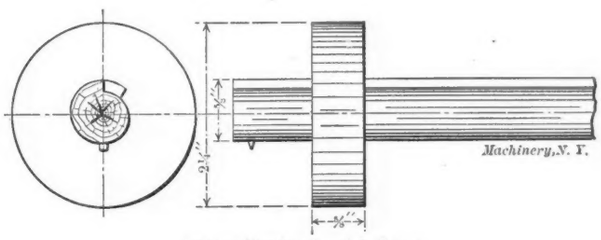
This is a good exercise for students in analytical geometry, and a test of the accuracy of their arithmetical work.

Syracuse, N. Y. WILLIAM KENT.

[While the above solution may be more elegant than a trignometrical one, and seem preferable to the mathematician for that reason, it involves considerably more arithmetical work, and requires more time for working out than the trigonometrical solutions offered in the August issue and in the present number. From a practical point of view, therefore, and for practical purposes, it seems that the trigonometrical solutions are to be preferred.—EDITOR.]

PATTERNMAKERS' SCRATCH GAGE.

The illustration below shows a patternmaker's scratch gage. This scratch gage is constructed entirely of hardwood (black walnut preferred). The stick is made the full length in the shape of a cam, in a uniformly increasing involute curve. The hole in the guide is made of the same shape as the outside of the stick, but the curve is carried about 5/16 inch



Quick-adjusting Scratch Gage.

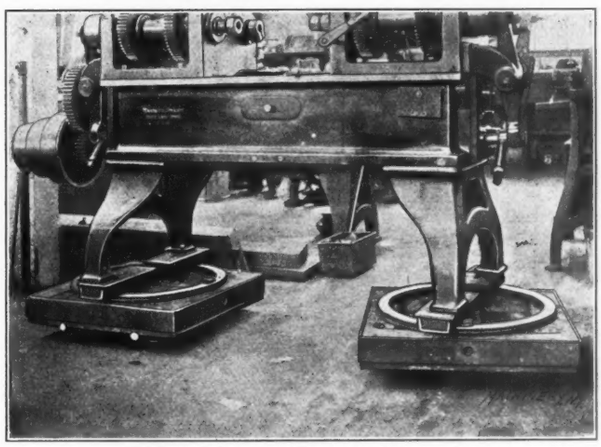
farther around, which makes it a little larger than the stick. Now, if the stick is slid into the guide, and then the guide revolved around the stick a quarter turn, it will clamp tightly. This makes a simple, neat, quick-adjusting tool for the patternmaker or carpenter. This gage is the invention of Mr. Ed. Therrian, of Two Harbors, Minn., and he has used it for years with great satisfaction. AUSTIN G. JOHNSON.

Two Harbors, Minn.

* * *

TRUCKS FOR MOVING MACHINERY.

In the September issue of MACHINERY we published an article by Mr. Ethan Viall, under the above title, descriptive of a small truck used for moving machinery, heavy castings, etc., about the shop, together with a drawing giving its prin-



Machine Tool mounted on a Pair of Trucks.

cipal dimensions. The accompanying illustration gives an idea of the usefulness of a pair of these trucks in a shop. As the top of the truck platform is comparatively close to the floor, heavy tools can easily be placed upon them and moved from one place to another.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.

Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

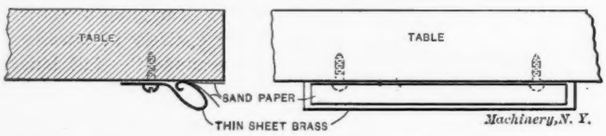
STAMPING TRACINGS.

To stamp names or headings on tracing cloth, use a rubber stamp with the ordinary red, blue or green ink found in inking pads. Before the ink has a chance to dry, sprinkle lamp-black over it, using an insect powder sprayer for the purpose. When dry, brush off with a piece of chamois skin. Stamping done in this manner will be found light-proof.

Aurora, Ill. JOHN B. SPERRY.

PENCIL SHARPENER.

The accompanying engraving represents a pencil sharpener or pointer. As seen from the illustration, it consists of a piece of thin spring brass bent to the form shown and fastened under the table near the edge by two round-head wood



screws. The sandpaper is held between the table and the brass spring. To sharpen the lead of the pencil, slip the point between the leaves of the sandpaper and move it back and forth. JOHN B. SPERRY.

Aurora, Ill.

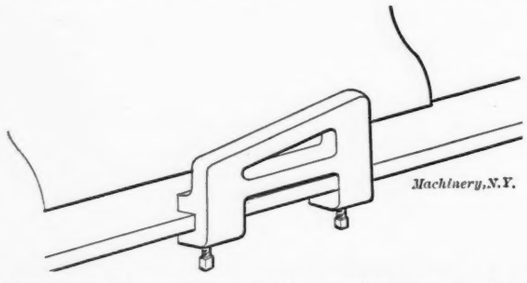
HARDENING DRILLS FOR DRILLING SPRING STEEL.

The difficulty of making a drill stand up when drilling spring steel is probably well known to all of the readers of MACHINERY who have had to do with this kind of work. The writer has been using the following method for hardening drills, with much success. A hole is drilled about ¼ inch deep in a piece of lead with the point of the drill to be hardened, care being taken that, when the drill is removed, the hole is not enlarged more than necessary to get the drill out. Then, the point of the drill is heated cherry red, and again placed in the hole and given a light blow with a hammer, and permitted to cool in the lead. It then will stand up much longer than otherwise. Turpentine is a good lubricant when drilling this kind of material. WILLIAM DAVIS.

Philadelphia, Pa.

HANDY ATTACHMENT FOR LATHES.

The accompanying illustration shows a handy attachment for lathes. The tapered slot in the casting holds the head of the set-screw in the dog when tightening it on stock. No



machine work is necessary in the construction of this tool, save the drilling for two set-screws; and the device saves many steps when wrenches are scarce and hard to find.

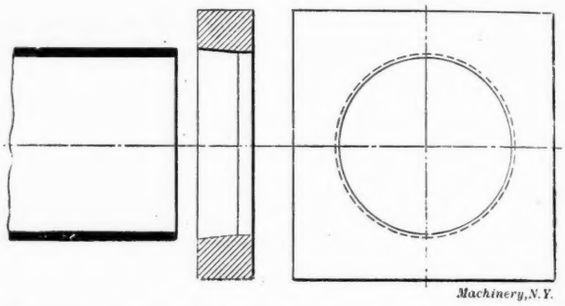
Middletown, N. Y. DONALD A. HAMPSON.

SAVING A TAP WARPED IN HARDENING.

The following method of saving a tap warped in hardening may be of special interest to those having to do with tools of this or similar description. The tap in question was of the expansion type, with a hole drilled longitudinally through its center, and reamed for a taper pin, which latter was used for expanding the tap. The total length of the tap was 20 inches, the diameter being 1¼ inch. A length of 4 inches in the center was threaded, leaving 8 inches on the one end for a guide and 8 inches on the other end for the shank. The tap was hardened, but when tried on its centers after hardening, it was found that it had warped and that there was not enough left on the shank and guide for grinding, so that the thread would run true with its guide bushings. To remedy this defect, a piece of brass was soldered onto each end of the tap, and after this was done, a piece of cast iron was chucked in the lathe and a hole bored and a thread cut to fit the tap, which was then screwed into this cast iron piece backwards, so that it would not cut its way through. The end which projected was then centered, the center being cut, of course, in the piece of brass fastened to it. When this was done the tap was screwed through the casting, the chuck was taken off and reversed, and the tap was screwed in from the back of the chuck, and the other end centered. The tap was now put on the new centers in the brass pieces and the threaded part, when tested, ran absolutely true. F. M.

TIGHTENING A BUSHING FOR PAPER ROLLS.

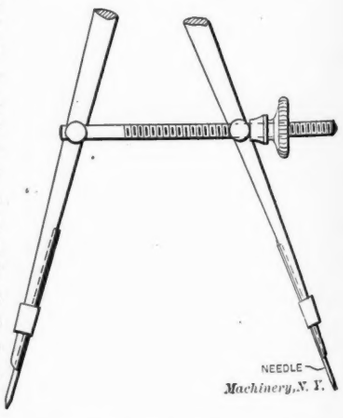
To the left of the accompanying line engraving is shown the end of a brass bushing placed on rolls used in paper mills for feeding the paper through the machines. The rolls are about 2 feet in diameter and 10 feet long, and the brass bushing, which is about ⅜ inch thick, became loose on one roll. The following method of tightening it proved very satisfactory,



and may be of interest to others. In order to diminish the size of the bushing so as to tighten it on the roll, a cast iron collar, shown to the right, was made, the smaller end of the taper hole bored in the collar being about 0.009 inch smaller than the outside diameter of the bushing on the roll. The brass bushing was next removed from the roll, and was forced through the collar, and then again pressed on the roll and turned true. E.

NEEDLES USED AS DIVIDER POINTS.

The engraving herewith shows the kind of divider points which I have on all my dividers and compasses. The inside of each divider leg is grooved about the depth of the diameter of an ordinary sewing needle, a needle is placed in the groove, and around the caliper leg and needle is fitted a band of brass. This band secures the needle to the leg as firmly as if they were one piece. This gives a hard, sharp, round point which can be thrown away when dull or broken. Die sinkers, tool-makers and machinists will find these the best divider points ever used. DIE MAKER.



[Sewing needles also make superior scribers for marking around templets on work requiring very exact duplication of outline and size. The points are much better than can be made by the average mechanic, being sharp, round, nicely tapered and of a fine temper. Of course, a suitable holder must be provided, but that is easy to make or buy.—EDITOR.]

NEW MACHINERY AND TOOLS.

A MONTHLY RECORD OF APPLIANCES FOR THE MACHINE SHOP.

CONSTANT-SPEED DRIVE FOR BROWN & SHARPE AUTOMATIC SCREW MACHINE.

The automatic screw machine, of whatever design, has usually been driven from the counter-shaft by at least two belts, one for the spindle and the other for the feed mechanism, with sometimes a third for driving the oil pump. The counter-shaft also has usually been provided with two shafts, one of constant speed, receiving power from the line-shaft and driving the feed mechanism, and the other for the variable speed drive of the spindle, the two being connected by a belt over suitable cone pulleys. As a consequence of this complication, the ceiling of a screw machine shop is completely covered with a mass of shafting, darkening the room, and causing trouble in the maintenance of the multitude of loose pulleys, hangers, clutches, etc. A large quantity of belting is also required. Besides this, the speed change, being made in the counter-shaft, is unhandy to operate, and rather difficult to keep in order, owing to the shortness of the belt on the cone pulleys.

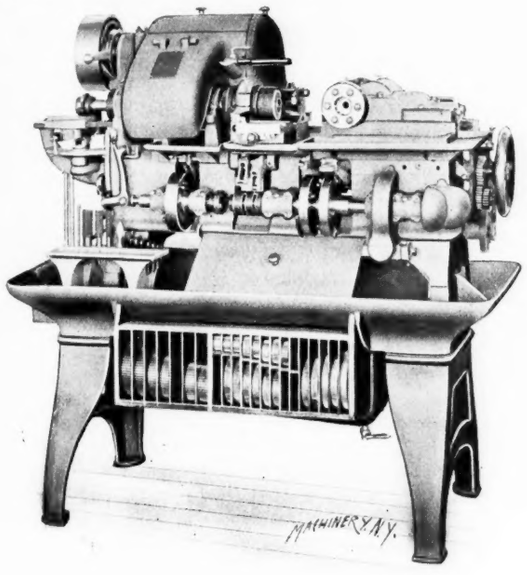


Fig. 1. Brown & Sharpe Automatic Screw Machine, Fitted with Geared Drive, Operated by a Single Constant-speed Belt.

The Brown & Sharpe Mfg. Co., of Providence, R. I., has recently designed for its automatic screw machine a constant-speed drive which does away with the various difficulties just mentioned, and gives to the screw machine, in addition, the same advantages that result in the application of the geared drive to other machine tools. The advantages include those of positive, strongly-driven feeds, self-contained mechanism, convenient manipulation, decrease in first cost and maintenance of belting and convenient provision for applying a constant-speed motor drive.

Fig. 1 shows a No. 2 automatic screw machine arranged with the constant-speed pulley drive, the construction of which is shown in Fig. 2. Flange pulley *A* is driven from the counter-shaft (or direct from the line-shafting, if preferred) by a constant-speed belt. This pulley, which is bronze bushed, revolves loosely on shaft *G*. A clutch, operated by a lever seen at the front of the machine at the rear end of the headstock in Fig. 1, engages or disengages sleeve *B* and pulley *A* as required, to start or stop the machine. Sleeve *B* has formed in it pinion teeth engaging gear *C*, keyed to back-shaft *D*, which is thus driven at constant speed. Change gears *E* and *F* connect shafts *D* and *G*, giving a choice of six speeds for the latter.

On shaft *D* is mounted a bronzed bushed quill having a pinion formed on it at *R*, and a larger gear at *O*, and having keyed to it a sprocket *P*. Gear *O* meshes with a mating gear *K* of the same diameter, which is pinned to sprocket wheel *L* and a clutch member *M*, which normally revolve loosely on shaft *G*. Sprocket wheels *P* and *L* are thus constantly connected with each other, and revolve at the same rate of speed in opposite directions. Pinion *R* meshes with gear teeth on the periphery of clutch member *J*. A suitable clutch mechanism, operated automatically, may be made to engage either *J* or *M*, through *H* or *I*, with shaft *G*. When *J* is engaged, sprockets *P* and *L* revolve in opposite directions at a high rate of speed. When *M* is engaged, the sprockets receive movements in the same directions as before, but at a slower rate.

The spindle of the machine has mounted on it, on roller bearings, sprockets *Q* and *N*, which are connected by chains with corresponding sprockets *P* and *L* in the driving mechanism. To *Q* and *N* are keyed the heavy clutch members *Z* and *X*, either of which, as required, may be engaged with the spindle by the movement of clutch *YY*, which is automatically operated. The rims *X* and *Z* are made heavy enough to have a balance-wheel effect, as shown. This relieves the strain on the chain and the driving gearing in the very sudden spindle reversal which is a feature of this machine. The throwing of clutch *YY* thus serves to reverse the spindle, while the operation of clutch *HI* changes the speed from fast to slow, or *vice versa*. This combination of automatic reversal and speed change has a special value in threading and work of similar character, where it is an advantage to employ one speed for turning and a slower one for threading. The

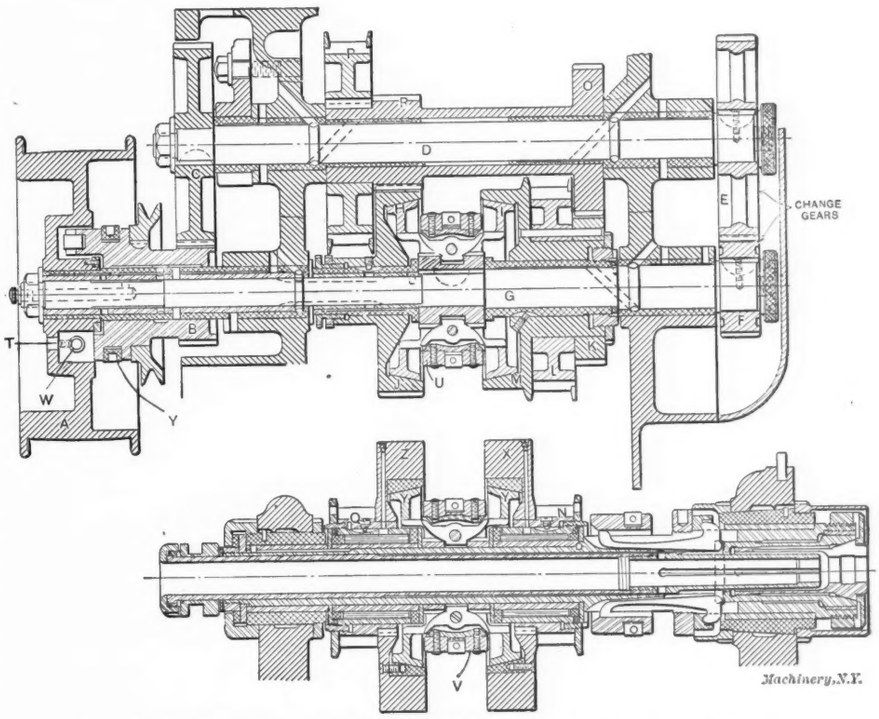


Fig. 2. Details of Construction of the Driving Mechanism, showing Provision for Automatic Reversal and Change of Spindle Speed.

speed change may also be employed in cases where the range of diameters turned, formed or drilled on a given piece is quite large, to permit all the operations to take place at suitable cutting speeds.

The feeding, operative, and idle movements of this machine, other than the revolving of the spindle, are driven by a shaft at the rear which runs at constant speed. This shaft is driven by a train of gearing, receiving motion from constant-speed gear *C* in Fig. 2. This connection includes a positive clutch thrown out by a lever at the front of the machine, so as to stop the feeding movements independently of the spindle. The power is transmitted through a shearing pin which furnishes a safety device in case of an accidental over-strain of the

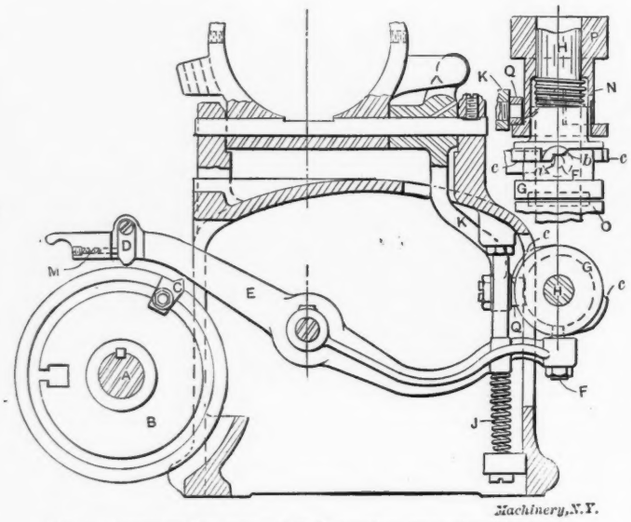


Fig. 3. Cross-section through Bed, showing Reversing Mechanism.

mechanism. On the back shaft, thus driven, is mounted a series of automatic throw-out clutches, similar in action to those used in punch presses. They operate various cams for controlling the feeding of the stock, the opening and closing of the chuck, the revolving of the turret, the reversing of the spindle and the change of speed from fast to slow or *vice versa*, the two latter movements being effected as previously described. Change gearing connects this back shaft *H*, see Fig. 3, through a worm drive, with a slow moving cam shaft *A* at the front, on which are mounted the cams for the turret and cross-slide movements, and a series of dog carriers and dogs which control the action of the various clutches on the back shaft. The change gears just mentioned determine the duration of the cycle of operations, and consequently the length of time it takes to make a given piece. The whole mechanism, as described, furnishes complete means for providing the various movements required in producing the parts for which the machine is set up.

In Fig. 3 is shown a section through the bed of the machine beneath the head-stock, which indicates the way in which the reversing movement is effected. There is a perplexing mechanical problem involved here which is solved in a very neat fashion. At *A* is shown the cam shaft at the front of the machine, to which is keyed dog carrier *B* provided with a T-slot in which are adjustably mounted dogs like the one shown at *C*. These dogs engage a tappet *D* on lever *E*, the rear end of which carries a screw *F* (locked by a nut) whose cylindrical point enters a cam groove in clutch *G*, mounted loosely on the constantly revolving back shaft *H*. A top view of the cam is shown in small detail above the position on the sectional view. The cam groove is exactly the same on the other side as on the side shown, the clutch being arranged to engage each half revolution and then automatically disengage. The normal position of the pin *F* is in the recess at *a*. When it is lowered entirely out of the groove by the action of dog *C* on tappet *D* against the pressure of spring *J*, this releases clutch *G*, which is forced forward by a spring *N* coiled about the shaft, until it engages a mating member *O*, fastened to shaft *H*, and is thus started to revolve. Meanwhile dog *C* has passed tappet *D*, allowing pin *F* to drop into the cam groove again. The clutch *G* as it revolves brings inclined face *b* of the groove (or a similar incline on the opposite side) into contact with *F*, and the continued revolution of *G*, through the action of this inclination on the pin, forces the clutch teeth out of engagement, stopping *G* again with the pin in position *a* as at the start. A cam *P*, also loose on the shaft *H*, is keyed to *G*. This cam engages a roll *Q* on the end of lever *K*, which operates a clutch fork, controlling *V* in Fig. 2. When it comes time to again reverse the spindle, another dog *C* is set in the proper position, and the clutch is again tripped, revolving for a second time a half revolution and stopping, operating lever *K* and the clutch fork to change the direction of rotation of the spindle back again.

This represents the normal procedure in cases where the time taken to make one piece is short enough so that the rotation of dog carrier *B* is reasonably rapid. For many pieces, however, this movement is so slow that dog *C* does not come out from under tappet *D* in time to allow pin *F* to drop into the cam groove before the clutch has made the required half revolution. In such cases, incline *b* having been passed without raising the clutch out, the pin can not drop in until the next recess comes along, and the next incline *b*, thus stopping the clutch at the end of one revolution instead of a half revolution. This difficulty has been very simply overcome by the following means:

Tappet *D* is pivoted to lever *E* as shown, and is forced back against a shoulder to the position indicated, by a spring *M*, located in a drilled hole, and pressing against a plunger bearing on *D*. This spring is of such strength as compared with spring *J* that the first effect of dog *C*, when it strikes *D*, is to move the latter backward without raising lever *E*. When *D* has been pressed so far back that it strikes the shoulder at the left, further movement being impossible, *E* is raised, pin *F* is withdrawn from the cam slot in the clutch *G*, and the the latter is allowed to engage fixed member *O* on the shaft *H*, and starts to revolve. A cam surface *c* is provided on *G* which, immediately after the commencement of the rotation of the clutch, strikes pin *F* and depresses it still further, thus raising tappet *D* clear above the point of dog *C*, and allowing it to swing back to its normal position against the shoulder at the right under the influence of spring *M*. Lever *E* is then at once ready to drop, *D* and *C* being entirely clear of each other. As soon as the end of cam projection *c* passes, *F* drops into the groove and the rotation of the cam is arrested on the half revolution as required. When it is stated that

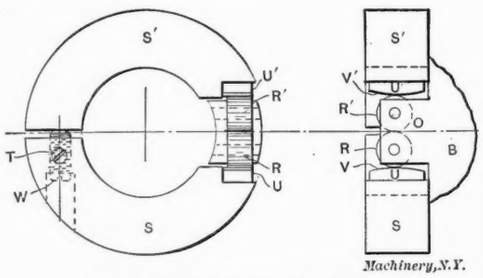


Fig. 4. Detail of Clutch Mechanism.

shaft *H* revolves at 120 revolutions per minute, so that the half revolution of *G* occupies but ¼ of a second, it will be seen that the device has a difficult duty to perform. It performs it in a very satisfactory manner. Dog carrier *B* may even be arrested as soon as the clutch is tripped, but the springing back of dog *D*, affected by the mechanism just described, will bring the points of *D* and *C* clear of each other, so that the latter is allowed to drop immediately and in time to stop the clutch. A second half revolution clutch and connected cam (similar in principle though somewhat differently arranged) is provided for controlling the fast and slow movements, as determined by the position of clutch *HI* in Fig. 2. A second set of dogs and a second lever are provided on the other side of dog carrier *B* for controlling this action.

The friction clutch in the machine driving pulley (see Fig. 4) is entirely new in design and differs greatly from the usual type of friction employed for this purpose. The driving pulley *A* carries a split friction ring *S* and *S′*, which is

expanded by two hardened rolls R and R' on the end of the sliding pinion sleeve B. These rolls operate against the hardened shoes U and U', the inner surfaces of which are arcs of circles. The sliding sleeve B is operated by a hand lever, conveniently located, whose fork engages the ring Y. To operate the friction, the rolls are forced in between the shoes a little beyond the centers of the arcs, thus expanding the ring and clamping it to the pulley. As the rolls are beyond the centers of the arcs, they remain locked in position. This rolling movement effects a powerful expansion of the ring, with but a very slight expenditure of force on the part of the operator. To compensate for wear, the friction ring is adjusted by the screw W and clamped by the set-screw T.

The grooved pulley, which is shown keyed to the hub of sleeve B in Fig. 2, is used for driving the various attachments with which this make of automatic screw machine may be fitted. This line of attachments includes those for automatic screw slotting, high-speed drilling in the turret, cross drilling on the cross-slide, and other similar devices. They are driven by a self-contained counter-shaft mounted as shown in Fig. 5, being attached to pads on the back of the headstock prepared to receive it. These pads are machined, drilled and tapped to accurate dimensions when the machine is sent out, so that the counter-shaft may be supplied and attached at any time by the purchaser. The various grooved pulleys shown, of different diameters, may be used as required to give the desired speed to whatever attachment may be in use at the time.

As may be seen from the details shown in Fig. 2, the whole mechanism is carefully designed to give an efficient and durable construction. The wearing surface and spindle bearings are amply proportioned to withstand the most severe service which a machine of this size and capacity should be subjected to. All the working parts are easy of access and readily adjusted, though carefully protected from chips and dirt. The driving chains are of the silent running design, operating quietly and efficiently at high speed. All the bearings in the spindle drive are bushed with phosphor bronze and, wherever considered advisable, the shafts are hardened.

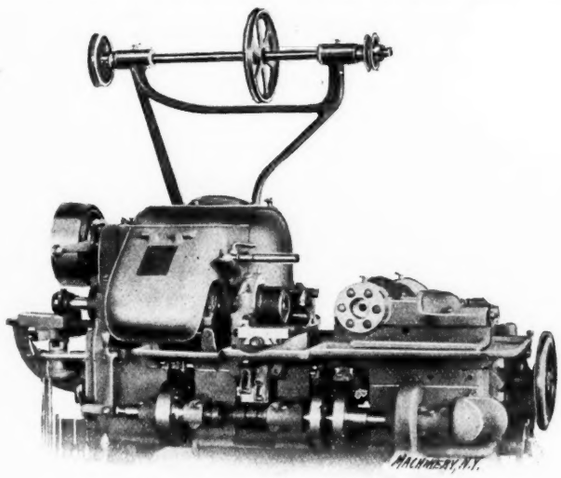


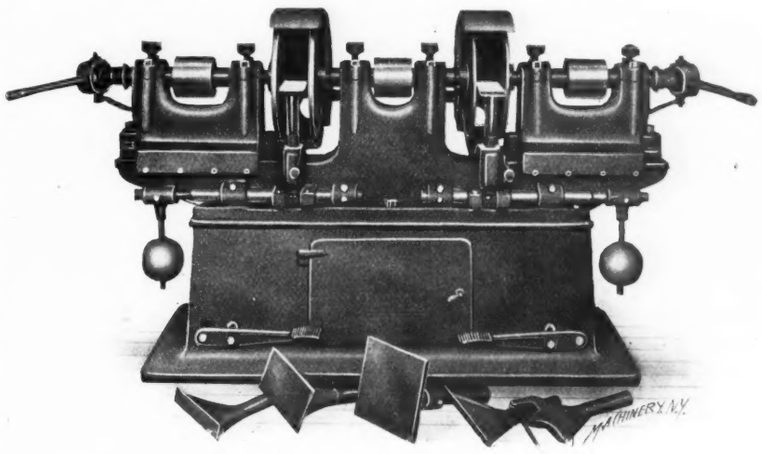
Fig. 5. Self-contained Counter-shaft for Driving Attachments.

FOUR-DISK GORTON GRINDER.

The maker of the Gorton disk grinder (The Diamond Machine Co., Providence, R. I.) has designed a form of that machine which carries four disks, and is adapted for grinding in two stages, work having parallel sides or sides at a slight angle with each other. One pair of disks does the roughing and the other pair the finishing, there being opportunity for using two operators on work of this kind.

The machine is provided with a heavy base on which the bed of the machine is mounted. Supported in bearings in the center of this bed is the main spindle, driven from the counter-shaft by a pulley between the bearings, and provided with a grinding disk at each end. The ends of the bed are machined to form ways on which slide the adjustable grinding heads, each of which carries a spindle and a grinding disk facing the corresponding one on the central spindle. These heads are adjustable on the bed to give any distance between the disks up to 12 inches. The heads are not mounted directly on the base, being clamped to saddles on which each has a swivel adjustment for any angle up to 10 degrees. This allows small angles to be ground at one setting.

The outer spindles have a longitudinal movement for feeding in against the work. This movement, which is limited by a micrometer stop, reading to 0.001 inch, may be effected either by the hand levers at the end of these spindles, or by the treadles shown on the base of the machine, the latter being connected with the hand levers by suitable link work. This foot-operated feed can be disconnected if necessary, though it does not interfere with the regular hand-operating device in any way. The work tables (which are furnished in various widths, or can be made specially to suit work difficult to hold otherwise) are adjustably mounted on counter-weighted rocking bars, as is usual in disk grinders, and may be swung in and out between the faces of the disks by hand levers projecting toward the front. The adjustable heads may be removed entirely if desired, and swiveled tables provided for the work, in which case the machine has all the adjustments of the standard machine.



A Four-disk Grinder especially adapted to Two-operation Work.

While this machine was originally designed and is here shown as a regular disk grinder, the disks may be replaced with chucks for holding emery rings, so that heavy grinding can be done. It will sometimes be found convenient to use a set of emery rings on one end of the machine, for roughing work which is finished between a pair of disks at the other end.

HAMILTON VARIABLE SPEED PLANER.

The two accompanying engravings show an improved form of planer drive built by the Hamilton Machine Tool Co., Hamilton, Ohio, which gives four changes of forward or cutting speed with a constant return, thus giving the machine the advantage of a variable cutting speed the same as has always been provided for other machine tools, such as lathes and milling machines. The changes are made entirely in the machine itself, and require no complication in the construction of the counter-shaft. Fig. 1 shows the general appearance of a planer so equipped.

The driving shaft has mounted on it four pulleys, only one of which, that for the return movement, is keyed to it. The others are: the loose pulley for the return motion, the loose pulley for the forward motion, and the forward driving pulley. The latter, as may be seen at the left of Fig. 2, is connected by gearing on the outside of the frame with a

secondary driving shaft parallel with and close to the main driving shaft. Inside the bed the main driving shaft has keyed to it a series of four gears of different diameters. The secondary driving shaft carries two sets of double mating gears, controlled by forks pinned to sliding rods. These rods may be manipulated by two handles shown on the outside of the bed at the left, so as to bring any one of the four into engagement with the mating gear on the driving shaft. The handles are so interlocked that it is impossible to engage more than one gear at a time.

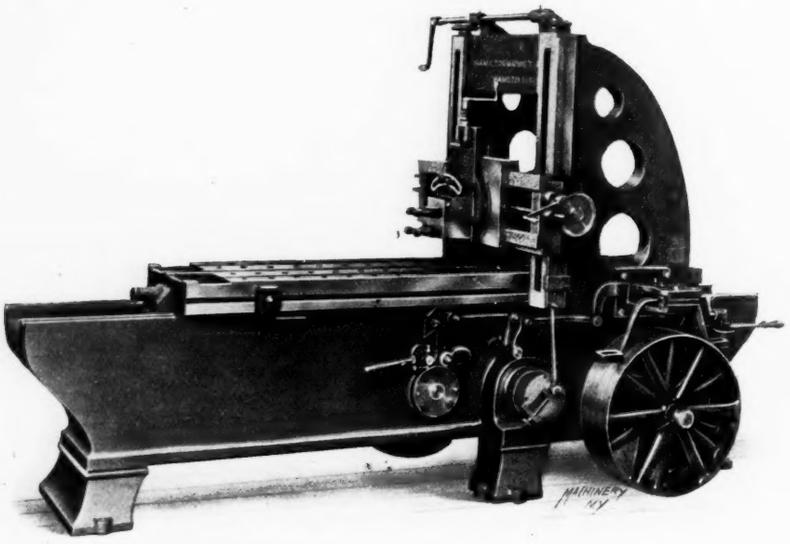


Fig. 1. 24-inch Hamilton Variable Speed Planer.

With any one of the four combinations of gearing in action, the drive is from the loose driving pulley through the outside gearing to the secondary driving shaft, and thence to the main driving shaft, through whichever one of the four pairs of gears happens to be engaged. From here the gearing connection is of standard form found on planers of the usual construction. On the reverse drive the movement is transmitted directly to the main driving shaft, to which the reverse pulley is keyed, the driving pulley running idly, meanwhile, from its connection through the change gearing and the outside gearing. One of the pair of outside gears is raw-hide, making a quiet running mechanism. The driving gears are of wide face and coarse pitch, running at comparatively slow speeds, and since only two of them are engaged at any one time, the action is smooth and durable.

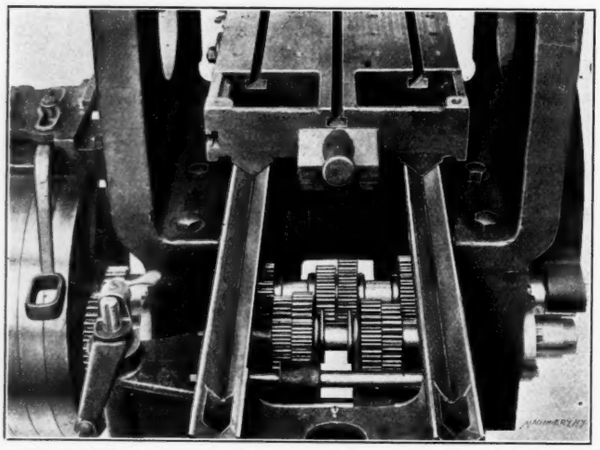


Fig. 2. Table run out to show Driving Change Gears in the Base.

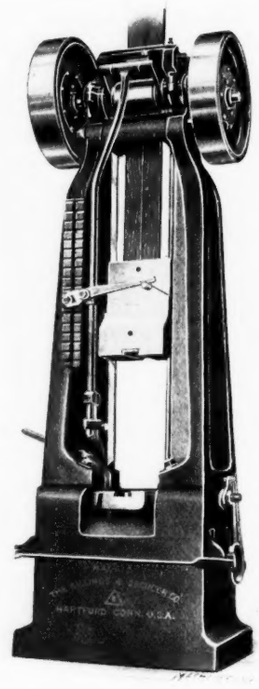
The placing of the gearing in the bed instead of on the housings overcomes any tendency to vibration, and locates it in a position which is out of the way and thoroughly protected, and yet easily accessible at any time. It is not intended that a speed change shall be made while the planer is running. While this is an advantage on some kinds of machinery, it is unnecessary on a planer, which has to be stopped to remove the work, rechuck it, or reset the tools prior to changing the cutting speed. For this reason the simple arrangement here provided can be used, giving, the builders believe, a much more satisfactory service than the complicated friction or tooth clutches sometimes used for such devices.

For the 24-inch machine, which is here shown, the forward cutting speeds usually provided are 20, 25½, 32, and 40 feet per minute, respectively, with a constant return of 80 feet per minute. Any reasonable variation may be obtained from these speeds by increasing or decreasing the speed of the countershaft, or by special modifications in the speed changing gears themselves made at the time the machine is built. By providing a two-speed countershaft, the number of cutting speeds may be increased to eight, though the four regularly furnished should be sufficient for the usual run of work. An index plate is attached to each machine, showing the different speeds provided and the proper location of the levers for each speed.

This variable speed drive, for which patents are pending, will be applied by the makers to any size of their line of planers of both the regular and widened patterns. It may be used for motor drive as well as for belt drive.

BILLINGS & SPENCER MODEL C DROP HAMMER.

The Billings & Spencer Co. of Hartford, Conn., has been making drop forgings for a period of about forty years. The firm has in that time used practically all the various forms of drop hammers on the market. The experience with these various hammers has, from time to time, given the company an opportunity to note their defects, and has suggested improvements. This led some twenty years ago to the building of hammers for use within the factory, and in this the firm has continued to the present time, bringing out successively the original Model A, a later design, Model B, and, finally, the machine here shown, Model C, which incorporates all the improvements suggested by the experience of the company in building drop hammers and using them. The new machine is intended to meet the demand for the much heavier work met with in the modern forging plant, where larger parts and harder materials are constantly being called for. This machine is not only much stronger than the old one for a given weight, but it also incorporates a number of distinctive features which will be mentioned in the description.



Billings & Spencer Model C Drop Hammer.

As shown in the accompanying half-tone, this hammer is of the board drop type, in which the weight is hung from a board which is raised by being clamped between revolving rollers. An improved board clamp catch is employed which

does away with the latch and connections at the side for holding the ram aloft. This clamp is located at the extreme top of the machine, above the friction rolls, where it is impossible for the oil to get between the gripping surface and the board, thus avoiding a most serious difficulty hitherto met with in some devices. This clamp, which is positive in its action, is controlled by clamps or eccentrics connected to a foot lever attached to the base of the machine. Another important feature of the tool lies in the adjustment provided for the rear friction roll. This adjustment is effected by means of an eccentric duplicating that used for the front friction roll. These two rolls, with their eccentrics, are therefore interchangeable. Owing to this construction, a true alignment between the lifting board and the rolls may always be preserved. A new form of bronze bushing is provided for these eccentric bearings, which may be easily and quickly removed and replaced. The attachment of the rear friction roll and the rear board clamp, which is also effected by an eccentric, are controlled by bars attached to the eccentrics and running down parallel with the uprights within easy reach of the operator on the floor. These bars are on the back of the machine and do not appear in the engraving.

The uprights used on the new model are of special design and greatly reduce the possibility of breakage, the distribution of metal being such as to afford a maximum of strength for the weight. The cross-section is that of the letter V, the apex, which is machined, forming the guide for the ram. A longitudinal rib running the entire length adds to the strength of the uprights. A feature of their construction is the fact that they are solid throughout their length, no weakening perforations being made for the fastening of attachments. The uprights are adjusted longitudinally on the base by a new and improved method, affording easy means of setting the dies. The releasing arrangement is attached to the front of the left-hand upright as shown. This may be placed in any one of a number of vertical positions at intervals of 1½ inch, allowing the ram to be released at any desired height.

COCHRANE-BLY AUTOMATIC SAW SHARPENER.

The metal-sawing machines made by the Cochrane-Bly Co., of Rochester, N. Y., employ a saw blade having teeth ground in the manner shown in Fig. 2. As may be seen, they differ

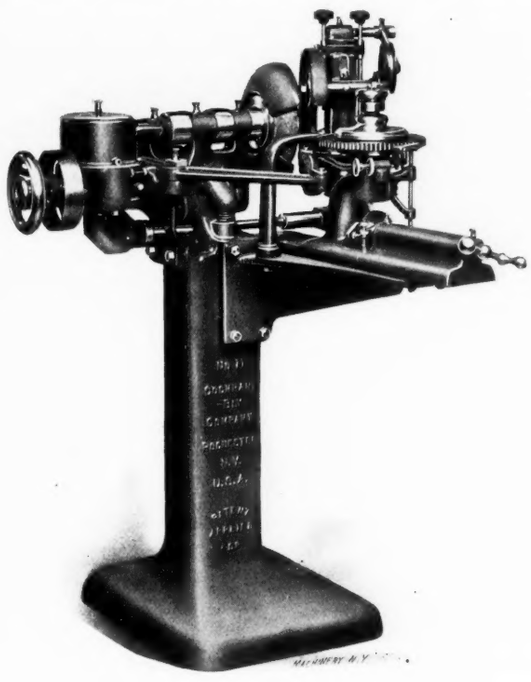


Fig. 1. A Machine for Automatically Sharpening and Beveling Metal-cutting Saws.

from ordinary milling saws in that every alternate tooth is beveled on each side to make a narrow cutting edge slightly higher than the other teeth. This high and narrow tooth takes a chip from the center of the cut, while the following wide tooth takes two, one from each side. The chips drop freely from the slot, reducing the heat and friction of cutting, and permitting greater feeds and increased production. While this form of tooth is thus a very efficient one, it is rather difficult to grind properly without special fixtures, and, to

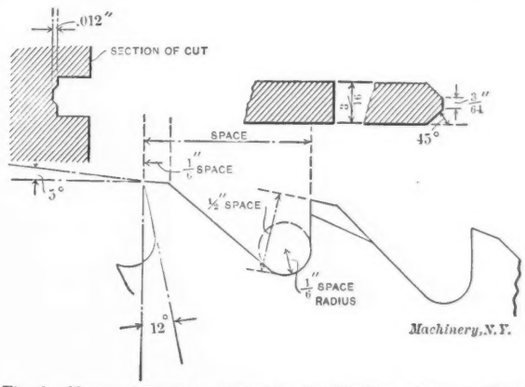


Fig. 2. Shape of Tooth produced by the Machine shown in Fig. 1.

obtain the best results, the grinding should be performed automatically, so as to give uniform spacing and height to the teeth. The interesting tool shown in Fig. 1 has been designed by the builders to effect this conveniently and accurately.

The saw blade is mounted on a spindle, with an index plate of the same number of teeth as the saw. The main

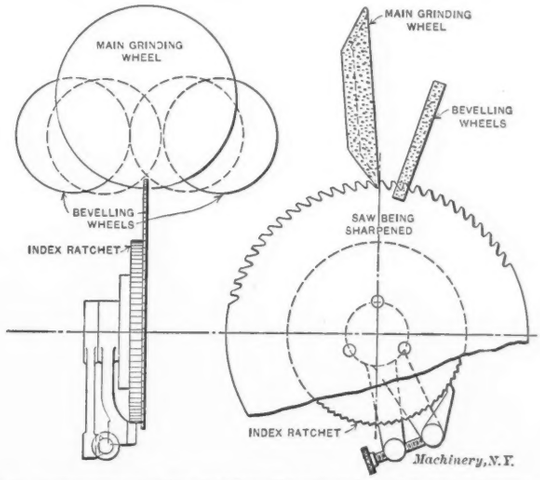


Fig. 3. Arrangement of the Grinding Wheels and the Saw to be Sharpened.

emery wheel spindle is carried by a swinging frame, operated by cams and levers which give it two movements, one of which feeds the emery wheel toward the center of the saw, grinding the face of the teeth, after which the wheel is backed out and fed across the top of the teeth to grind the land. The frame is, of course, set to give the proper angle of tooth for each of these faces, and as the feeding movement starts at the point, it leaves the cutting edge sharp and free from burrs. This action takes places on every tooth with identically the same movement, except that each alternate tooth is ground about 0.012 inch lower, the high teeth being the ones that are subsequently beveled.

The beveling is done by a pair of wheels mounted on a standard at the back of the work spindle support. They are attached to a slide which is reciprocated vertically on the standard by a cam, so as to alternately grind the upper and lower beveled corners of the alternate teeth. This is done while the main grinding wheel is working on the preceding tooth. The beveling wheels are raised from the work on each alternate low tooth. After each tooth has been ground, the saw is indexed by means of a cam-operated index lever engaging the ratchet wheel indicated in Fig. 3, and shown in Fig. 1, each tooth being thus brought to a certain fixed point, insuring even spacing. Fig. 3 shows plainly the relative positions of the wheels and the saw.

The spindle carrying the saw and index plate is set in a slide mounted on a bracket attached to the frame of the ma-

chine. This slide is adjusted by the hand screw on the bracket to accommodate the saws of different diameters. An adjustable automatic movement is provided for feeding the blade toward the emery wheels after each revolution of the saw, until enough stock has been removed to sharpen all the teeth properly. A special saucer shape is used for the main grinding wheel, which keeps its outward shape as it is worn down, and does not require constant dressing to produce the proper form of tooth. The cam movement of the machine governs the shape of the teeth.

The design of the machine shows evidences of having been carefully worked out. All the working parts are well protected from dust and dirt, the bearings being provided with covers and felt washers. The spindles are hardened and ground and the fitting is carefully attended to throughout the machine. There is but one adjustment, that which governs the depth of the teeth. This should vary according to the pitch and diameter of the blade. The capacity of the machine is for saws from 10 inches to 24 inches in diameter. The main emery wheel is 8 inches in diameter, while the beveling wheels are 5 inches in diameter. The net weight of the tool is 388 pounds.

HACKETT TWISTED DRILL.

Twist Drill made from a Flat Bar of Stock throughout its Entire Length.

The drill shown in the accompanying engraving is made from a twisted flat bar of stock throughout its entire length, and may be held in a socket or machine spindle finished to the regular Morse taper standards. This, as shown, is accomplished by increasing the twist at the shank of the drill so as to form a good bearing, and grinding the spiral which is thus formed to fit accurately a Morse taper hole. The extreme end of the twisted bar is left straight and serves as a tang entering the slot in the socket, thus driving the tool in the same way as is done with a drill of the usual construction.

The construction of the tool is so obvious and so simple that little more need to be said about it. It can be made very inexpensively and of any suitable grade of steel, carbon or high-speed. It is lighter, and therefore easier to handle, and less expensive for stock than drills as commonly made, milled as they are from the solid bar. It will be noted that there is a tendency on the part of the tool to grip firmly into its taper seat under the pressure of the cut, as this causes the spiral to unwind somewhat, thereby increasing its diameter and causing it to expand tightly in the hole. These drills are sold by George E. Hackett, 90 West Street, New York City.

CORBIN-CHURCH HIGH-SPEED DRILLING MACHINE.

The Corbin-Church Co., New Britain, Conn., has designed a 13-inch high-speed drill which is built in two different styles to suit the requirements of the purchaser. These two styles are shown in the accompanying half-tones, Fig. 1 showing the machine as a sensitive drill, and Fig. 2 the same machine with power feed applied. These drills are designed especially for the use of high-speed tools.

The column is a solid casting with supports for the spindle and the various shafts required for the drive. The counter-shaft is contained in the machine and is provided with 8-inch tight and loose pulleys for 2-inch belt. A 3-step cone in the counter-shaft is connected by a belt with an idler cone, which in turn drives the spindle pulley by a quarter-turn belt running over suitably placed idlers The strain of the belt on the driving pulley is taken by the sleeve on which it is mounted, leaving the movement of the spindle sensitive to the slightest touch. The large diameter of the pulleys used permits running the belt at a low tension while still furnishing sufficient driving power, thus prolonging the life of the belt greatly.

The spindle is balanced and is provided with a micrometer adjustment stop-collar on the sleeve for drilling to suitable

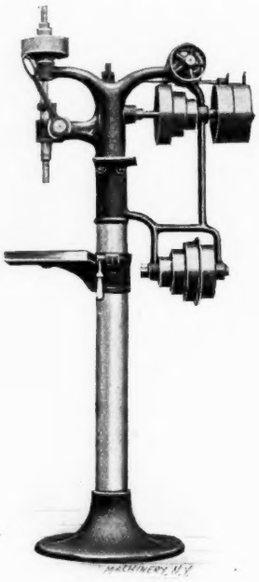


Fig. 1. Corbin-Church High-speed Sensitive Drill.

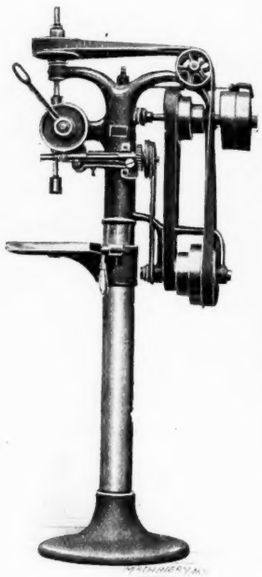


Fig. 2. High-speed Drill with Power Feed Attachment.

depths. This stop-collar may be adjusted without stopping the machine. A special index is provided for measuring the depths of holes. The spindle is of tool steel and provided with a ball thrust bearing. The table is balanced by a weight inside the column. An index line is provided on the column for bringing the center of the table in line with the center of the spindle.

The power-feed attachment, shown applied in Fig. 2, is driven by a round belt from the idler cone-shaft, over a pair of 3-step cones which give a corresponding number of changes of feed. A drop worm and worm-wheel delivers the power to the feed pinion-shaft and furnishes means for providing an automatic stop. A special feature of the power-feed machine is the overbalancing of the spindle, and the automatic release of the feed, which allows the spindle to fly back to its starting position again at the conclusion of each cut. This leaves the operator nothing to do but put in and remove the work, and start the feed. This attachment is particularly useful on the multiple spindle type of this tool.

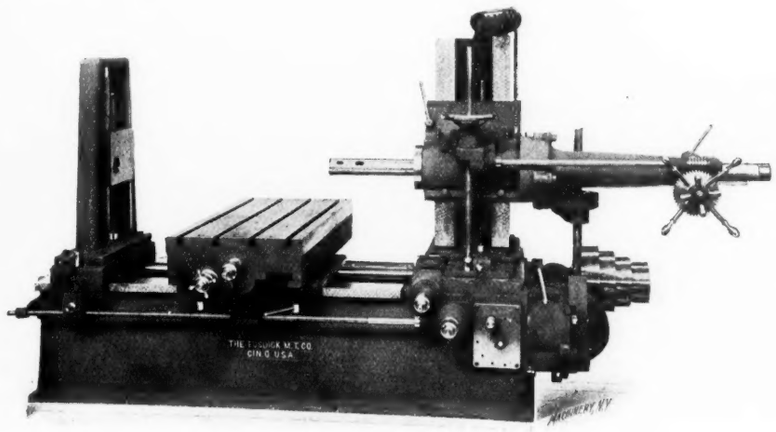
This machine gives the maximum range of 33 inches from the end of the spindle to the table, and a distance of 6⅝ inches from the center of the spindle to the column. As a single spindle machine it weighs about 325 pounds. It will be furnished with any number of spindles up to six. The makers invite comparison in design and workmanship with any other similar drills made.

FOSDICK HORIZONTAL BORING, DRILLING, AND MILLING MACHINE.

The accompanying illustration shows a horizontal boring, drilling, and milling machine brought out by the Fosdick Machine Tool Co., Cincinnati, Ohio. The illustration shows very plainly the general features of the design of this machine. The builders have particularly endeavored to make the machine convenient to operate, as this factor governs the output of any machine to the very largest extent. All levers and hand-wheels have consequently been placed on the operator's side, and within easy reach. The safety feature of operation

has also been given due attention, and all gearing and moving parts have been thoroughly encased. All the gears are made of steel, and provisions made for adjustment for wear of the spindle and alignment of the spindle with the outer support bearing. The outer support can be entirely removed if required, and independent adjustment provided for alignment if the operator should change the position of the head while the support is removed from the machine.

The spindle travel and the cross-feed of the table are actuated by power in either direction, and are equipped with graduated dials for micrometer adjustments. The diameter



Fosdick No. 0 Horizontal Boring, Drilling, and Milling Machine.

of the spindle is 3 inches in the driving sleeve, and 1½ inch in the rear sleeve, the end thrust being taken by ball bearings. The spindle is provided with a No. 5 Morse taper socket. There are eight spindle speeds, ranging from 12½ to 155 revolutions per minute, all being reversible. The feed changes are eight in number, varying from 0.007 to 0.250 inch per revolution of spindle. The spindle travel is 22 inches, and the vertical head travel, 21 inches. The lateral travel of the table is 36 inches, and the cross-feed, 28 inches. The working surface of the table is 50½ by 23½ inches. The table is provided with four T-slots and six stop holes.

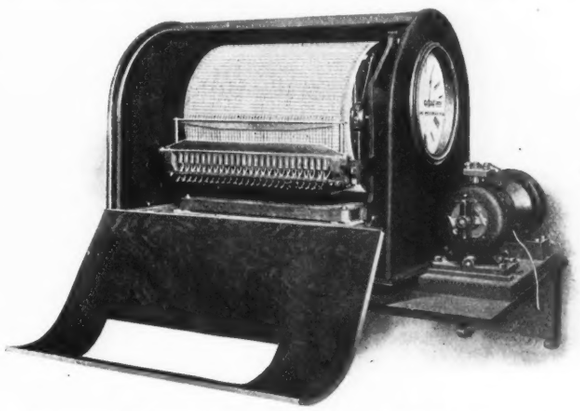
The drive is positive throughout and two mechanical changes are made with positive clutches. A 3-inch double belt is used on the cone pulley or on the constant-speed driving pulley. The counter-shaft has friction pulleys for forward and reverse, and is run at 400 revolutions per minute. When motor-driven, a 5-horse-power motor is recommended, and the motor can be direct connected to the machine through spur gearing. A constant speed motor can be applied to the machine in connection with the regular gear box for speed changes, or a 3 to 1 variable speed motor can be applied. The machine illustrated in the accompanying half-tone is termed by the makers as style No. 0. This machine requires a floor space of 13 feet in line with the spindle by 7 feet 8 inches traverse width, this latter dimension permitting the table to travel to its extreme limits. The net weight of the machine is 7,500 pounds. In addition to the No. 0 machine, two larger size machines, Nos. 1 and 2, are also built.

NATIONAL MACHINE RECORDER.

The instrument shown herewith, made by the National Machine Recorder Co., Marquette Building, Chicago, Ill., will automatically indicate and record the length of time that each of fifty machines is actually running, and the length of the corresponding idle periods. It consists of a revolving drum to which is attached a record sheet about 16 inches wide and 45 inches long, which is rotated evenly by clockwork and furnishes a complete record for twelve hours. Mounted in front of this rotating drum is a series of 50 metallic points or markers, each of which is controlled by an electromagnet connected in circuit with a switch attached to the counter-shaft of the machine whose working it is desired to record. When the belt shifter or clutch lever is thrown to start the machine, the circuit is connected, and the corresponding magnet, through the recording mechanism, pushes the metallic point down until it presses on the paper, where it traces a line on the revolving surface as long as the machine is in operation. When the machine is stopped, the circuit is broken, and the metallic point drops back from the paper, breaking the line on the recorder. The fifty record lines are 5/16-inch apart, and the sheet is graduated horizontally in lines 1/16 inch apart, one for each minute, so that very accurate and easily read records are kept, it being possible to estimate the time as closely as within one-half minute. The device may be set up in the superintendent's office or that of any other official, without reference to the location of the machines to be recorded, except for the requirements of making the necessary wiring as short as possible.

The uses of such an instrument from the standpoint of the works manager are obvious. One of these is the matter of estimating the efficiency of the individual workman as far as concerns the wasting of time. A glance at the recorder will, in many cases, serve to show that a machine has been idle very much more than it should have been. Upon investigation, it can then be determined whether the difficulty lies with the machine or with the workman, and remedial measures applied.

The apparatus will also prove to be of the greatest value to the cost department in showing the length of time actually spent on work. In the case where the workman keeps his own record, the divisions of the time difference between jobs is notoriously inaccurate, the inaccuracies being due sometimes to carelessness and occasionally to design. The plan sometimes adopted of having men report to a time-keeper at the commencement and conclusion of each job is wasteful of time, and is not necessarily much more accurate than in the previous method. By the use of this instrument, however, in connection with the record of the work given out to the operator, it is possible to determine the time for commencement and completion of each job with the utmost accuracy, with the added advantage of knowing how much was spent in the changing from one operation to another. Having this accurate record on even the shortest jobs, it is possible to com-



Instrument for Recording, Automatically, the Length of Time Machine Tools are Idle or in Operation.

pare the time of the same operation in different lots, and by different workmen, and thus arrive by course of comparison and analysis at an estimate of the proper cost for given operations and given parts.

This leads to the consideration of what would undoubtedly be the most useful function of the device in shops where the piece-work system is in vogue, namely, the setting of suitable rates for piece-work. In some plants, tests are made to determine what time should be required for each operation, and so establish piece rates. In most plants, however, owing to the complication of operations and the impossibility of properly forecasting the time without special training, this is done in a more or less haphazard manner. In such plants

there exist what are known among the piece-workers as "good" and "bad" jobs, evidencing the fact that the piece rates in force are either too high or too low. The common method followed in such places is to determine the length of time consumed in producing a certain output by day work, increase this output 10 or 15 per cent, and divide the quantity into the amount earned, the result being the piece-rate. This might be accurate if some workmen in the modern factory did not anticipate a piece rate on operations which are now being performed by day work, and did not use their ingenuity to curtail production, and keep the manager in ignorance as to what the actual output should be, so that when the piece rate is established it would be one at which it would be easy to make regular day wages.

With this machine, however, the actual length of time the machine has been producing, the duration and time of day of each producing period, and their idle moments are recorded. As the speeds and feeds are always subject to the foreman's supervision and the record shows whether or not a machine has been kept in operation for a suitable length of time, it is possible from the start to set an equitable rate of production for any given operation, and piece rates may be established with a reasonable degree of confidence.

The device should also prove a spur to the works manager himself. When the records are examined, the idle periods will doubtless seem unnecessarily long and it will be his place to investigate the reason for the delays in getting started on new work, in changing work in the machine, sharpening tools, and performing the other operations that detract from the cutting time of the machine. Such an investigation would naturally lead to a better system of shop management down to the smallest details. Since the record is made while the operation is in progress, it is possible to stop leaks of this kind at their inception. Without such a record most of the irregularities would never be discovered, while those that would be found out would come so late that investigation would be practically fruitless. This device was originally designed for the use of engineers interested in increasing production, and has proved a most valuable adjunct to that work.

STURTEVANT TYPE H ELECTRIC MOTORS.

The B. F. Sturtevant Co., Hyde Park, Mass., has designed a line of motors especially adapted for direct connection to the blowers and exhausters built by the same firm. They are of the 4-pole type, simple and compact in design and pleasing in

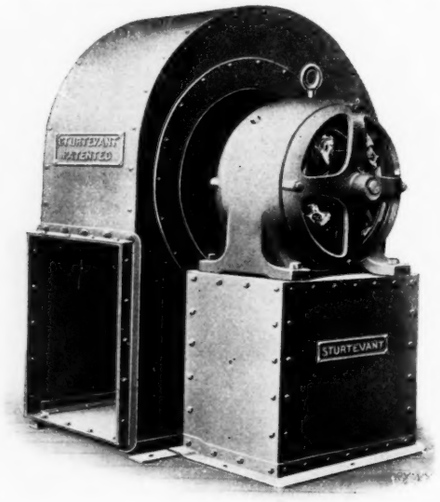


Fig. 1. Sturtevant Type H Electric Motor, connected to Blower.

appearance, as may be seen by reference to Fig. 1, which shows one of them connected to the blower.

The magnet frame is of cast iron with pole pieces bolted to the frame and located off center to permit the use of duplicate bearing brackets on each end. By taking out the through-bolts, the pole piece with its field coil may be removed without disturbing the armature or dismantling the motor. The pole pieces are built up of soft steel punchings secured between end plates while under pressure. They are of such shape as to afford a support to the field coil and so distribute the magnetic flux as to produce sparkless commutation under wide variations of load. Cast iron horns are provided to eliminate the disagreeable humming noise otherwise consequent to the use of laminated pole pieces. The field coils are machine wound, carefully insulated, and protected in the most

Fig. 2. View of Dismantled Motor, showing Construction.

improved manner against moisture or mechanical injury. The view of the machine dismantled in Fig. 2 will show the construction of these parts very plainly.

The armature is of the iron-clad, slotted-drum type built up of soft annealed steel punchings, each insulated by a coating of japan. The punchings are assembled on a cast iron sleeve provided with openings for the full circulation of air. This is shown better in Fig. 3, where the direction of the current

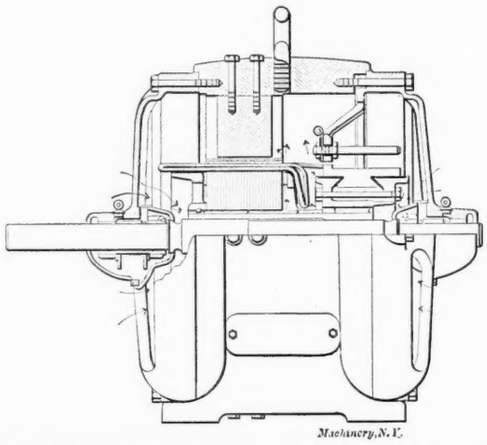


Fig. 3. Half-section illustrating the way in which a Free Circulation of Air is obtained.

is indicated by arrows. The whole arrangement forms a fan exhauster between the armature and the commutator, taking in air at both ends. As may be seen in Fig. 3, the sleeve has an extended hub for the reception of the commutator shell, thus making the armature and the commutator a self-contained unit. The coils are of double cotton-covered copper wire or strap held in the slots by fiber wedges, thus preventing the stripping of the bands. The commutator is built of bars of hard drawn copper held in a cast iron shell of spider construction. Great care is exercised in selecting the mica, to have it of the same hardness as the copper, so that the wear of the two substances will be uniform. The whole commutator is assembled while hot under great pressure; thus each bar is held firmly in place, and the liability of its working loose reduced. The brushes are of carbon, and are held in holders of the sliding socket type provided with a braided copper pigtail, which relieves the brush holder body and springs of the necessity of carrying the current. The holder is supported by a ring seated in the machined recess in the magnet frame and clamped in position by the front bearing bracket. There is thus no danger of the brushes being thrown out of position or tilted, as is the case when the brush rigging is clamped by set-screws.

These motors are designed to be as efficient as any motors built of the same size and speed, but have capacity for great

over-load. They will carry 50 per cent over-load for an hour without destructive sparking or heating, and will carry 100 per cent over-load for 5 minutes. These characteristics show their great adaptability for driving fans, particularly in factory service, when the fans are often over-loaded. Special pains have been taken to keep the heat-rise low. Tests made in clean dry places have shown the heat-rise for open and semi-enclosed motors less than 72 degrees F. at normal speed and output. These motors are made in a complete line from 1 to 100 horse-power in order to meet the requirements of all installations. Though primarily fan motors, they are applicable to the regular work of driving machine tools, etc.

THE NUTTER & BARNES AUTOMATIC SAW AND CUTTER SHARPENING MACHINES.

We show herewith in Figs. 1 and 2, illustrations of two machines made by Nutter & Barnes Co., 326 A St., Boston, Mass., for automatically sharpening gear and milling cutters, and for sharpening and beveling saw teeth. In these machines the cutter or saw is clamped in place, and automatically indexed, the machine spacing the teeth past the grinding wheel and feeding the latter back and forth across the face of the saw, or cutter. At the completion of each revolution of the latter, the wheel is fed in by hand until all the teeth are sharpened.

The saw and milling cutter sharpener, shown in Fig. 1, is an inexpensive machine intended for general shop and factory use wherever milling saws and cutters of various kinds within the range of the machine have to be sharpened. Saws from 2½ to 6 inches in diameter, and of any ordinary thickness, may be ground. Those which are badly worn may have a new set of teeth ground in them at very little expense, as the machine does not require close attention after being started. Old milling cutters of any diameter ranging from 2½ up to 6 inches, and for straight faces as wide as ⅝ inch, may also have their teeth renewed. An attachment at the rear of the machine is provided, by means of which the teeth may be easily backed off.

Fig. 1. Automatic Saw and Milling Cutter Sharpening Machine.

A feature of the machine is the indexing of the work by accurate index plates 6 inches in diameter. The use of these insures accurate spacing in the grinding, and permits the reshaping of teeth as described. They are also particularly useful in sharpening gear-cutters. This may be done with absolute correctness, so that the teeth will be spaced regularly and radially from the center line. This it is difficult to do in the ordinary manner without an index and means of holding the cutter central with the grinding wheel. Two index plates cut with any desired number of teeth are furnished with the machine. All the change necessary in going from one cutter to another is to change the arbor bushing and the index plate, and this is a small matter, but very few minutes being required. The machine should be particularly profitable in the matter of reshaping old saws and cutters which have been

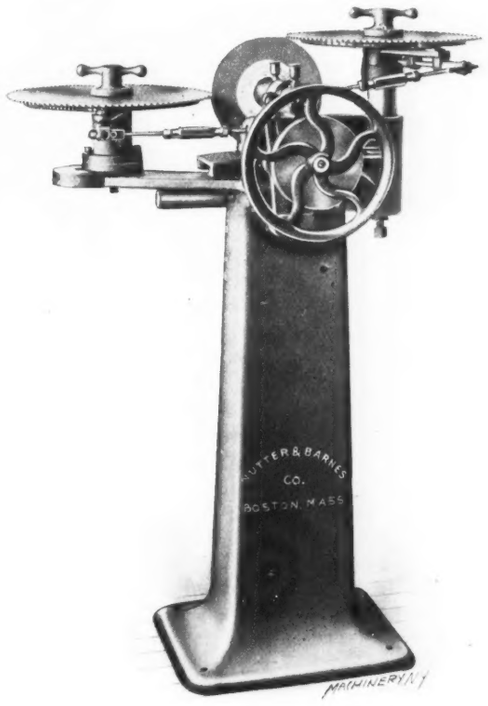


Fig. 2. Automatic Saw Sharpener and Tooth Beveling Machine.

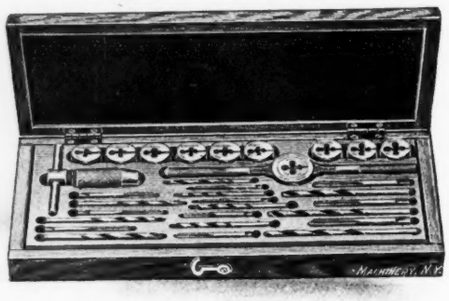
abandoned on account of the teeth having become too shallow. These can have new teeth ground at much less expense than would be required for annealing, re-milling and re-hardening them.

In Fig. 2 is shown an automatic saw sharpener and tooth beveling machine of somewhat similar construction. In this case, also, the spindle is indexed from a ratchet wheel cut accurately to a number of spaces corresponding with the number of teeth in the saw. The reciprocation of the grinding wheel and the indexing are automatic. The feeding of the wheel to depth, however, is done by hand. Two index plates, one for sharpening and one for beveling, are furnished with the machine, covering the saws provided with the builder's cutting-off machine. For special index plates an extra charge will be made. At the rear of the saw-sharpening arrangement is placed the tooth beveling device, by means of which every other tooth may be beveled on opposite sides, thus relieving them of half of their thickness, while the cutting face remains the full thickness of the blade. This form of tooth breaks up the chip and allows the saw to run much more freely, practically eliminating the liability of its sticking when cutting soft stock. In no tooth, when so ground, is the full width presented to the surface of the cut. The saw is indexed in this operation the same as for sharpening, except that the index plate is set for half the number of teeth in the saw, skipping every other one. After the bevel has been completed on one side of the saw, it is turned over and treated the same as on the other side, for the alternate teeth.

REECE SCREW PLATES.

The illustration shows a screw plate set brought out by E. F. Reece Co., Greenfield, Mass., which is supplied in six assortments. The principal feature of novelty of the new screw plate set is that a Morse twist drill is provided for each size of tap, the drill, of course, being the correct size for drilling the tap hole. This feature makes a screw plate set complete, it containing all tools required for threading screws, nuts or tap holes.

Another feature of interest is a T tap wrench for holding the taps. These tap wrenches are made with spring-tempered tool steel centers in two sizes, having a range from 1/16 to 1/2 inch. These screw plate sets are made in machine screw and



Reece Screw Plate Set, with Tap Drills.

fractional sizes. The machine screw assortment No. R. D. 3 cuts No. 2 to No. 16, inclusive, and the fractional sizes cut from 7/64 to 1/4 inch, inclusive.

BEAMAN & SMITH DUPLEX BORING MACHINE FOR AUTOMOBILE CYLINDERS.

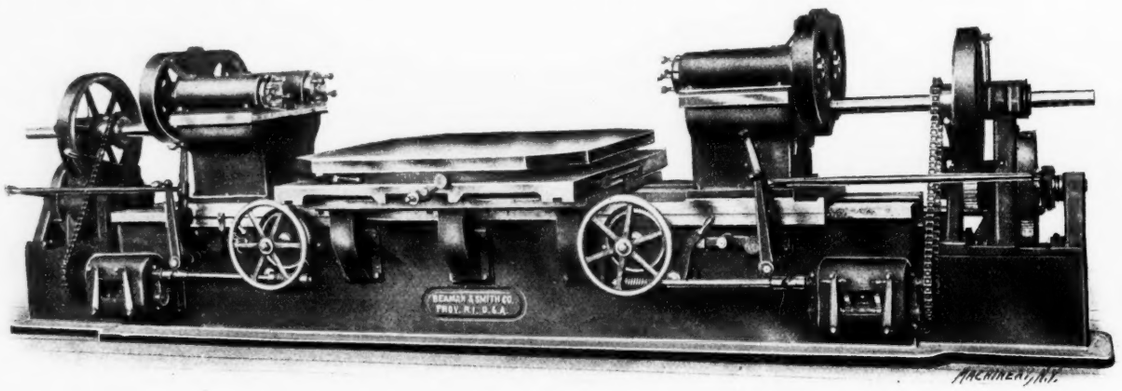
The special boring machine shown herewith, built by the Beaman & Smith Co., Providence, R. I., combines a number of interesting features of design. It is of the type which has been called in England the "snout" boring machine, in which an overhanging rotary cutter head is fed in to the bottom of a blind cylinder bore. The operation corresponds to that of boring in the lathe, to the extent that the members of the machine are subject to a constant deflection, the tool having constantly the same over-hang from the beginning to the end of the cut. This is not the case with a boring-bar supported front and back, and fed through supporting bushings. By making the heads very strong and rigid, it is possible also to use multiple cutters, four being commonly used for roughing and six for finishing. This method of boring was described in an editorial in the May, 1906, issue of MACHINERY.

The general construction of the machine designed by the Beaman & Smith Co. for employing this method of boring automobile cylinders, is plainly evident from the engraving. A work table is provided, pivoted so as to be swung around a cross-slide carriage, which is supported on the center of the bed. Sliding on ways on the bed on each side of this revolvable work table are two boring heads, each provided with two heavy spindles fixed in position, so far as center distance is concerned. The work is clamped to the revolving table opposite these spindles, and the heads in which they are mounted are fed forward on the bed until the boring tools have reached the bottom of the bore, when the feed is thrown out by an automatic stop. The heads are then quickly returned by power, allowing the table to be revolved and new parts to come in place to be machined.

The revolving table permits the clamping of work in place at the sides of the machine, while those presented to the spindles are being bored. At the completion of the operation, after the heads are withdrawn, the table may be indexed to bring the new pieces in position to be bored, leaving the completed parts ready to be taken off and replaced with unfinished work. This permits the machine to be in operation continuously, it being necessary to stop the boring only long enough to return the heads and index the work table. Another method of employing the revolving table, involves the use of roughing cutters on one head-stock and finishing cutters on the other; in this case, the work is indexed step by step. At the conclusion of each operation it is carried from the roughing head to the intermediate position at the rear of the machine, and then to the finishing head at the next move, finally returning to the intermediate position at the front of the machine, where it is removed and new work inserted.

Another important point in the design of the machine relates to the construction of the bearing surface on which the boring heads slide on the bed. As will be seen from an examination of the engraving, the support for the central table is raised above the bed, being mounted on three brackets attached to it on each side. The boring heads are bolted to carriages which extend for a considerable distance forward of the cutting tools, thus bringing the line of direct pressure within the bearing surface which supports the heads. This provision does away with the excessive wear at the front of the bearing surface which would otherwise take place and result in a pitching forward of the heads and a consequent disalignment of the machine.

The work table is clamped in its four positions by a lock bolt entering corresponding slots in hardened blocks, held in recesses on the under side of the table. These blocks are adjustable in their positions by screws on the upper surface of the table, so that the dividing can be done accurately at any time after the completion of the machine to make each indexing exactly 90 degrees. The carriage rotates on a ring of balls, making it very easy to swing around from one position to another. The table and the carriage are clamped together by a split reverse V-ring which brings these two parts down together firmly all around their whole periphery, and makes the table practically solid with the carriage. The short weighted lever seen just at the front of the cross slide is used to withdraw or insert the locking bolt for indexing the work table.



An Automobile Cylinder Boring Machine provided with a Rotating Table, permitting the Setting of Work while the Machine is in Operation.

The carriage itself is adjustable crosswise of the machine on the base by which it is supported. This adjustment is guided by another bearing at the center to keep the movement accurately at right angles to the line of travel of the spindle. The movement is not a sliding one, there being no vertical pressure on this central bearing, and the vertical pressure at the edges being taken by a train of rollers on each side. Suitable clamps are provided for binding the carriage firmly to the base when the adjustment has been made. Instead of using fixed stops to locate the successive cross positions of the carriage required in boring multiple cylinders (or a series of single cylinders mounted side by side) a contact point and multiplying pointer are used to indicate the reaching of any desired position. Distance pieces of the required length are inserted between this contact point and the finger of the

pointer, thus providing for an accurate setting at the various cross distances desired. This is much more satisfactory than the using of stops, which probably could not be set in line with the thrust of the screw, and which would, for other reasons as well, give varying results in accordance with the degree of pressure applied to them.

The two ends of the machine are driven entirely independently. A driving shaft extends the length of the bed at the rear of the machine. This is connected by suitable gearing, as shown, with the splined shafts which lead to each of the heads. The connection with each of these splined driving shafts is through a friction clutch controlled by levers at the side of the bed in convenient position for inspecting the work, so that either may be stopped independently of the other. Each member is also provided with an automatic power feed driven by a sprocket-wheel and chain, as shown, from the driving shaft, and connected through a change gear box which gives four rates of feed. A drop worm and automatic stop are provided, so that the feed is arrested when the proper depth of boring has been reached. For the rapid handling of the head, a power traverse is provided, controlled by the lever seen just in front of the clutch lever on each end of the machine. Each head thus has independent controlling mechanism throughout.

LAPOINTE BROACHING MACHINE ARRANGED FOR BROACHING TAPERS.

The broaching machine built by the LaPointe Machine Tool Co. of Hudson, Mass., has recently been adapted by its builders to the broaching of taper holes. The machine thus

Fig. 1. Arrangement of Head and Cutter-bar for Broaching Tapers in the Lapointe Machine.

arranged is shown in Fig. 1, while Figs. 2 and 3 show, respectively, the shape of the hole broached and the construction of the cutting tool by which the operation is performed. It is evidently impossible (except in the case of holes as large as in the job described in the July, 1908, issue of MACHINERY) to complete the forming of a square taper in one operation. This would require, as in the case there described, that the broach be made in sections, which must be guided in such a way as to travel in paths at the proper angle with each other to give the required taper. In the case of small work like that here shown, the plan is followed of cutting one corner of the taper at a time, and then indexing the work to four successive positions until each corner has been cut, which thus finishes the entire hole.

The work performed is indicated in Fig. 2. As shown, the hole to be broached is first finished with a taper reamer slightly larger at the large and small diameters than the width across the flat sides of the finished taper hole at the large and small ends. This gives a little clearance space for the broach to run out into on each of the operations. This round tapered hole also serves as a seat for the taper bushing on which the work is supported during the cutting operation, and as the broaching does not entirely clean out this hole, the bearing remains to the completion of the final operation. The work bushing and head may be seen in Figs. 1

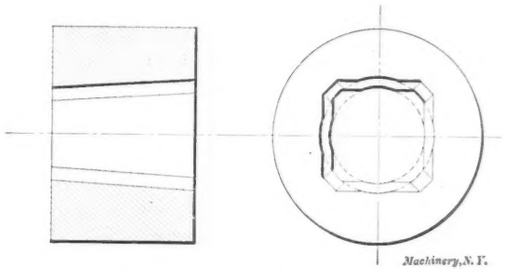


Fig. 2. The Taper Hole to be Broached.

and 3. The work bushing, turned on its outside to the taper of the hole in the blank, is mounted at the head of the machine on a base which is inclined to the angle of the corner of the internal taper to be cut. In a groove formed on the under side of this tapered work bushing, slides the broach or cutter bar, having teeth formed in it after the usual fashion of such tools, smaller at the inner end and gradually increasing in height to the outer end until they conform to the full depth of the cut to be made. The work, of which several pieces are shown at the base of the machine in Fig. 1, has clamped to it a dog, as shown, with a slotted tail, adapted to engage any one of the four pins disposed equi-distantly about the edge of the disk which forms the base of the taper work bushing.

In operation, the broach having been run out to the extreme of its travel, the work is inserted over the broach and pushed on to the taper work-holding bushing, and is located as to angular position by the engaging of the dog with one of the four pins as described. The machine is then started up and the broach is drawn back through the work, cutting out one of the corners. Then the blade is again run out, the work is drawn off by the taper bushing far enough to permit rotating it until the dog engages a second pin, when the operation is repeated, cutting out a second corner. The other two corners are successively finished in the same way, thus completing the machining of the hole to the form shown in Fig. 2.

It may be noted that while the hole shown has flatted corners, these are not required, as the broach can be made with a

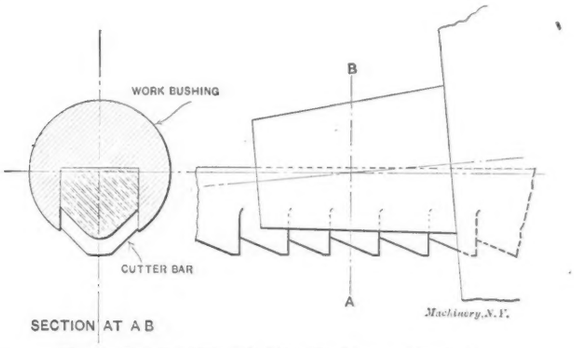
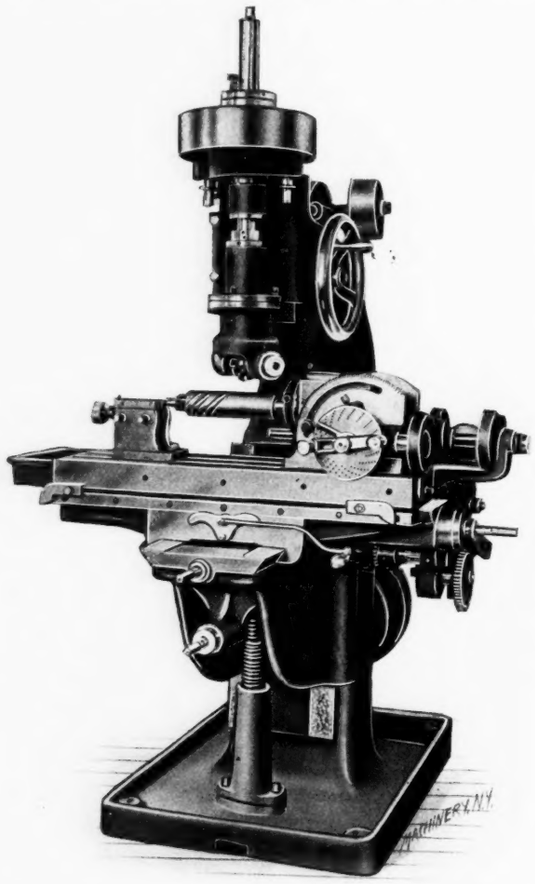


Fig. 3. Detail of Work-holding Bushing and Broach.

sharp corner if necessary. In all cases, however, it is necessary to leave a portion of the taper hole in the flat of the square, as shown in Fig. 2, so as to center the work with the bushing. Less of the circle, however, can be left than is shown in the engraving. For instance, at the large end the round taper hole need be only about 0.010 inch deeper than the square to be cut.

SPIRAL CUTTING ATTACHMENTS FOR THE BECKER VERTICAL MILLING MACHINE.

In the May, 1908, issue of MACHINERY, in the department of "New Machinery and Tools," we illustrated a horizontal attachment for the vertical miller built by the Becker Milling Machine Co. of Hyde Park, Mass. This horizontal attachment, it will be remembered, bears the same relation to the vertical milling machine, that the vertical attachment often furnished by horizontal milling machine builders bears to their product. It is adjustable at any angle about the axis of the spindle, the movement taking place in a horizontal plane instead of in a vertical plane, as in the case of the



Spiral Cutting Attachment applied to Becker Vertical Milling Machine.

regular column and knee type machine. The builders of this attachment have recently designed the arrangement herewith shown, for providing a universal spiral and dividing head and connecting it with the table feed-screw. This device permits the cutting of spirals and doing other work which is strictly within the province of the universal milling machine.

The accompanying engraving shows the horizontal attachment and the spiral cutting arrangement mounted on the vertical milling machine, using a regular spiral head as provided with the builders' line of horizontal millers. The connection with the feed is made by means somewhat similar to that employed in the case of the circular milling attachment, with which this type of machine is often provided, except that both the table feed and the feed for the head are used simultaneously, while the ratio between them is varied by change gears to give a suitable range of spirals adapted to the general run of work of this kind. When set to the proper ratio, the operation of the table feed revolves the work spindle of the index head through the indexing mechanism, in the same way as in the universal miller.

The cutter, of course, for spiral work, has to be set at the helix angle of the groove to be cut. In the universal milling machine this is effected by swinging the table about a vertical axis. With the arrangement here shown, a corresponding effect is produced by swinging the spindle of the horizontal attachment about the axis of the spindle of the machine. This can be done with the same facility as in the universal miller, it being possible to center the cutter while the spindle is at right angles to the axis of the work and adjust it afterwards to the helix angle without altering the center adjustment. This makes the arrangement much superior to the devices oftentimes used on horizontal machines for somewhat similar purposes, where the cutter is usually mounted off the center of angular adjustment so that it cannot be centered with the work conveniently. Another advantage over the attachment for the horizontal machine, is in the simpler motion obtained, it being necessary to change the axis of the revolving spindle through but one right angle turn instead of two.

The machine is also, when thus arranged, more adaptable in some respects than the universal milling machine without attachments, since it is unlimited in the matter of angular settings, it being possible to bring the cutter spindle to positions between 45 degrees and a line parallel with the work—an adjustment impossible in the universal miller, where the table usually has 45 degrees of adjustment on each side of the center. The arrangement gives the same facility for cutting spiral tapers, etc., that the universal miller does, and would seem to cover its field quite effectively. The machine to which the attachments are shown applied in the engraving is of an older style, which is soon to be replaced with a new line, which the builders are now preparing for the market.

AUTOMATIC TRIMMING MACHINE FOR BOLT HEADS.

When ordinary machine bolts with square or hexagon heads are produced by the cold-forging process, the heads are first forged circular, and special trimming machines are employed for producing the square or hexagon heads by trimming off the superfluous metal by a trimming process. In the following, a machine for automatically trimming bolt heads, placed on the market by the E. J. Manville Machine Co., of Waterbury, Conn., is illustrated and described.

In order to make the principles of the machine clearer, a few words may be said on the subject of cold-forging of bolts. The bolt blank with its circular head is produced in a heading machine, in a manner as indicated by the three illustrations in Fig. 1. In the heading machine the wire is taken from the coil, straightened, and fed a predetermined distance until a cutting mechanism cuts it off to the required length. A die

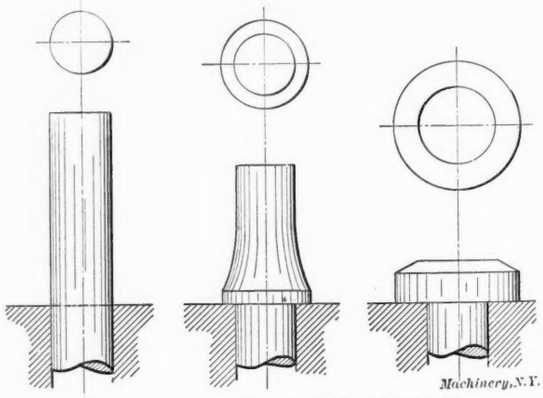


Fig. 1. Successive Steps in Cold Forging Bolts.

then receives and protects that portion of the blank which is to form the body of the bolt, and a punch compresses the projecting end of the blank into a preparatory cone shape, as shown in the central view, Fig. 1. Finally, a finishing punch forms the head to a circular shape.

When the bolt blank is thus finished it passes to a trimming machine. Ordinarily the trimming operation is performed on a vertical power press, each bolt being placed by hand so that its body or shank is pushed up into a hollow punch, while the head is trimmed to the required shape. This process, however, is neither rapid nor safe, and the automatic bolt and head trimmer illustrated in Figs. 2 and 3 has been designed for rapidly carrying out the trimming operation.

The most important feature of this machine is the feeding device which must handle automatically several different sizes of work. The feeding device consists principally of a feed hopper, provided in its center with an oscillating slotted blade. This blade raises the blanks, holding them by their heads, and is pivoted at a point outside of the hopper. This lifter or blade is made of two plates of steel, riveted to a separating piece, the lower end of which is acted upon by a

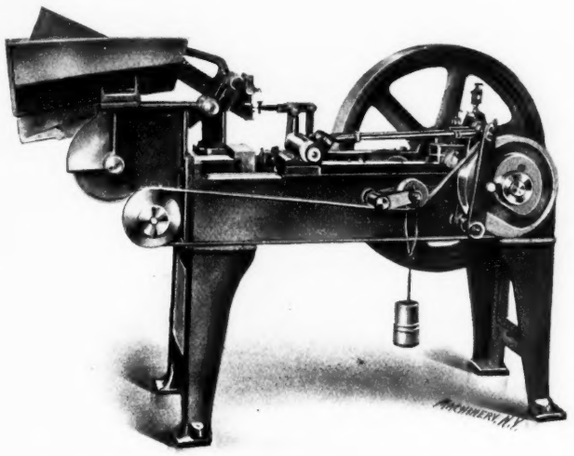


Fig. 2. Manville Machine Co.'s Automatic Bolt Head Trimmer.

crank-pin and roller projecting from the face of a plate gear. This gear, in turn, is rotated by a pinion on the end of a short shaft driven by a belt on a 2-step pulley, the power being thus transmitted from the main crank-shaft, as clearly illustrated in Fig. 2. As the slotted blade passes upward through a quantity of headed blanks, several blanks will be lifted by their heads at each stroke. Owing to the incline of the blade when in its upper position, the tendency of the suspended blanks is to slide toward the lower end. A continuation of this sliding way is constructed of two stationary plates, as may be seen most clearly in Fig. 3, in which may also be seen the heads of several blanks automatically placed in proper position by the feeding device. At the junction of the stationary

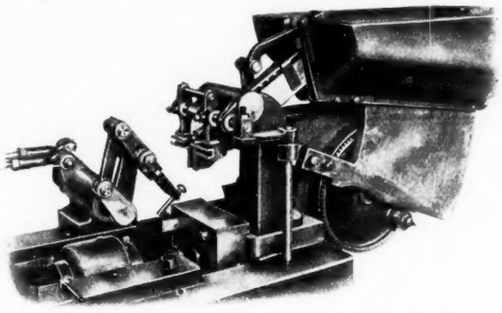


Fig. 3. Feeding Mechanism of Bolt Head Trimmer.

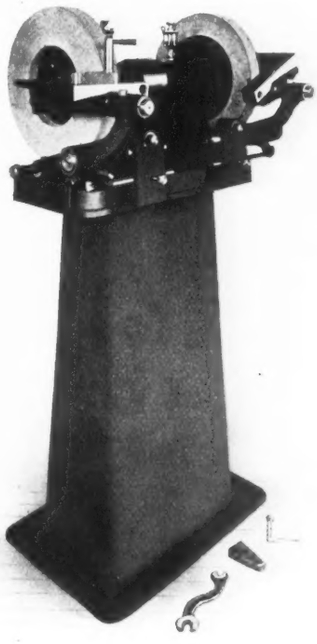
tracks and the lifting blade of the hopper, a device is introduced which stops the progress of every blank not properly delivered to the fixed track; this device returns such blanks to the hopper, and thereby insures a continuous action at the lower end of the race-way. A mechanically-actuated device holds back the descending column of blanks, and, at the proper moment, the lowest blank is separated from those behind it and forced outward into the spring jaws of a special carrier or transferring device as shown.

The blank is now transferred from the vertical position which it has had at the outlet point of the feeding device to a horizontal position in line with the punch and die for trimming the head. The mechanism by means of which this is accomplished consists of two rocking shafts working on the same center, each being moved through an arc of about 90 degrees by two cams on the crank-shaft of the machine. On the inner ends of these two rocking shafts are arms, to one of which is pivoted the finger lever holding the spring fingers which receive the blank from the feeding device and deliver it to the dies. A link joins the end opposite the spring finger and connects it with the second rocking shaft, thus forming, as will be seen in Fig. 3, a parallelogram or linkage by which it is possible, with properly shaped cams, to cause a bolt held by the fingers to move in a predetermined path and place it in a horizontal position. When the bolt has reached the proper horizontal position, it comes to a rest until the hollow end of a square- or hexagon-ended punch advances a sufficient distance onto the end of the blank, at which moment the fingers move up to clear the punch.

The swinging fingers and their holders are easily removed from the finger lever and replaced by other fingers when a different diameter of bolt is to be handled. Means are provided for adjustment, so that the bolt will be placed in perfect line with the trimming tools at all times. When trimming the head, the punch advances on the shank or body of the blank until it reaches the under side of the head, when its further advance pushes the bolt head against the die and finally into it, thus shearing the head to the required shape. The punch then recedes, leaving the bolt in the die until, at the backward stroke, the bolt head is pushed out of the die by a knock-out pin.

EMMERT FACE GRINDING MACHINE.

The accompanying illustration shows a machine designed and built by the Emmert Mfg. Co., Waynesboro, Pa., intended for the grinding of lathe and planer tools, for squaring up ends of work, and for miscellaneous grinding in the toolroom or machine shop. As will be noticed from the illustration, the machine embodies several features in which its design differs from the common design of this kind of machine. One of the novel features is the provision for the use of a diamond for truing up both the side and the periphery of the wheel. This was made because the builders of this machine realized the difficulty of obtaining a true side on an emery wheel by an ordinary emery wheel dresser. A straight edge or surface on tools and a straight face on the edges of work is easier and more accurately obtained by using the side of the wheel than the periphery, provided the side is straight. To permit both the side and the periphery of the wheel to be used for grinding, the work table is located in front of the side of the wheel, and extends in front of the periphery, as shown. The table is carried by a transversely swinging arm, and in the end of the arm is a longitudinally adjusted diamond holder. When the table is in use, it may be either clamped to prevent any transverse rocking movement or adjusted to allow a certain amount of such movement, which is often of advantage when grinding wide work. When truing up the wheel, an adjustable stop below the table is moved out, and the table swung backward away from the wheel. In this position, the diamond is swung across the face of the wheel for truing purposes.



Emmert Mfg. Co.'s Face Grinder.

The table is designed to slide longitudinally and is provided with a threaded hole to receive the diamond holder, which can be transferred to this hole when the edge of the wheel is to be trued. The table slide is mounted on a pivot

in the swiveling arm, and can thus be clamped at any angle, up to 45 degrees, with the face of the wheel. Graduations are provided for proper setting. On the table is also provided an adjustable squaring device or protractor, which may be set from 45 to 90 degrees with the surface of the wheel. The wheel spindle of the machine is hardened, and runs in adjustable bronze boxes. A water tank of ample capacity is provided for cooling the work. The wheels used are 12 inches in diameter by 1½ inch thick, and are recessed in the center as shown.

UNIVERSAL BORING, MILLING AND DRILLING MACHINE.

The machine shown herewith is built by the Universal Boring Machine Co. of Hudson, Mass. As may be seen from Fig. 1, it is of the type in which the work table is provided

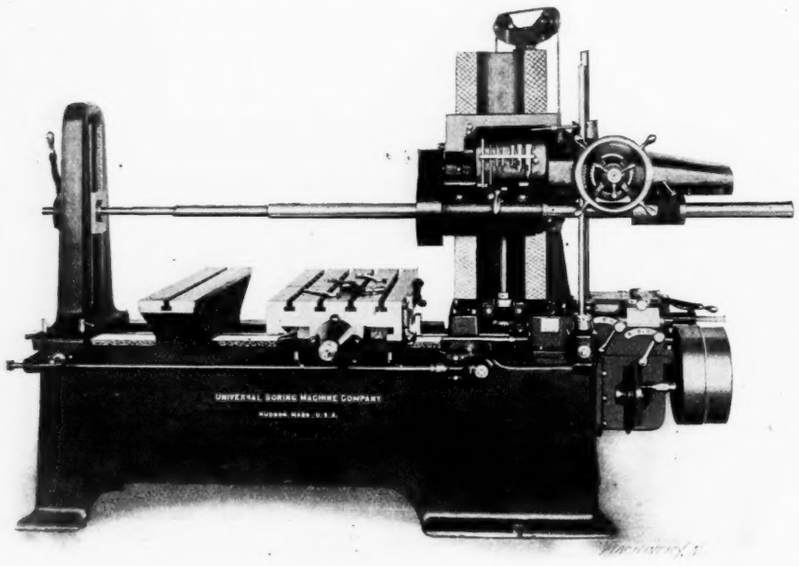


Fig. 1. The Universal Boring Machine Co.'s Universal Boring, Milling, and Drilling Machine.

with longitudinal and cross movements on a stationary bed, and in which the spindle is mounted on a saddle in such a way as to give it longitudinal movement in its bearings and a vertical movement, provided by the adjustment of the saddle on a stationary column. While the machine thus conforms to a type, the details of the design have been worked out in a very original and ingenious fashion. Some of these details are illustrated in Figs. 2, 3 and 4.

In the first place, it will be noticed that the head is set at the right-hand end of the bed, contrary to previous practice in some other machines of this type. This arrangement permits running the spindle in the same direction for milling as for boring and drilling, and is convenient as well for the operator, who has the various controlling levers within easy reach of his right hand when closely examining the work. The base is of solid construction, and furnishes a suitable support for aligning the parts with sufficient accuracy to perform the high grade work for which the machine is intended. The column has guiding surfaces for the head so arranged that the latter is squared up by a comparatively long and narrow guiding surface, and at the same time it is provided with a wide area over which to distribute the wear. This guiding bearing has a length six times its width. In addition to this point, it should be noticed that the gibbing on one edge of the column is arranged with a square lock gib on the side nearest the work. One of the bearing surfaces on which the head moves is provided with a scale, which is graduated and marked in inches. The zero point indicates the position in which the center of the spindle is in a line with the top of the table.

An outboard support for boring-bars is provided, as shown, which is adjustable along the bed. The outboard bearing, which is gibbed to the internal guiding surface of this support, is raised and lowered by a screw connected by a spiral gearing and splined shafts to the elevating screw of the spindle head, so that the two move together simultaneously. A rapid raising and lowering movement is provided for the head. This may very profitably be used in connection with the vertical graduated scale just mentioned, making it possible to stop the rapid movement within ⅛ inch of the desired setting of the spindle. From this point the hand adjustment is used to bring the dial on the elevating screw to a position to read the proper dimension in thousandths of an inch.

The boring-bar is driven from tight and loose pulleys operated by a belt running at constant speed. The loose pulley is provided with a method of self-oiling which does not require attention oftener than once a year or thereabouts. The design of the lubricating device is very simple, it consisting only of a hollow receptacle cast in the hub of the pulley, and filled with cotton waste which is saturated with oil, the latter being led to the bearing by a strip of wicking. Sixteen positive geared spindle speeds are provided, eight of them being obtained by a geared quick change mechanism, and this number being doubled by back gearing mounted in the head close to the spindle.

The construction of the speed box is shown in Figs. 2 and 3. To the driving shaft is keyed a cone of 4 gears *L*, fastened together, and capable of being shifted endwise by arms pinned to a rock-shaft *M*, which passes out through the front of the case. Here it has fastened to it a lever *A*, with a lock pin engaging four holes in the front of the casing, each of which corresponds to a position of the cone of four gears. On a shaft parallel to this driving shaft is mounted the tumbler gear arrangement shown in Fig. 2 and in detail in Fig. 3. This consists of a double rocker arm *N* mounted loosely on the shaft (though confined axially) and provided with pivots on each side of the shaft. On one of these pivots is mounted an idler gear *O* meshing with a small gear keyed to the shaft. On the other is mounted an idler meshing with a larger gear keyed to the shaft and pinned to a gear *P* having a position corresponding to the idler on the oppcsite pin of the rocker arm. This rocker arm has teeth cut in a segment of its

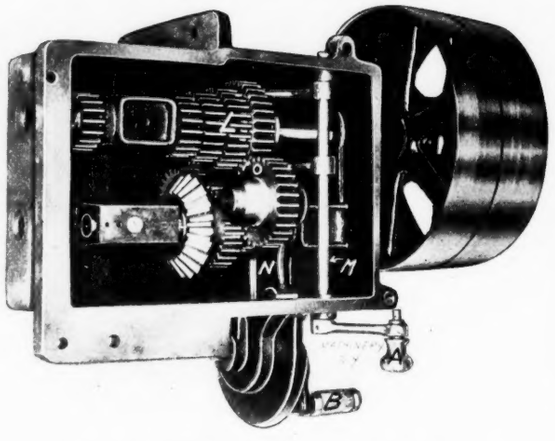


Fig. 2. The Change-gear Box which gives Eight Speeds.

periphery which mesh with a pinion operated by a crank *B* from the outside of the gear casing. This crank is provided with a pin which enters suitable holes in the casing, and thus determines the angular position of the rocker arm and the idler gears mounted on it.

The shifting of the cone of four gears and the rocking of the segment to which these idlers are pivoted, provides means for furnishing the changes of speed. In the position

shown in Fig. 2, the cone of gears is shifted so as to bring the largest one of the four in line with the pivoted idlers. In changing from one speed to another, these idlers are set in the neutral position, which allows the cone gears to be shifted freely without hitting them. When shifted to any given position, the holder carrying the idlers can be rocked to bring either the upper or the lower one into mesh with the gear presented for engagement, the position being located by the holes in which the lock pin on lever *A* is seated. The engaging of the upper or lower idler for each gear gives two speeds. This in combination with the four gears, gives eight

Fig 3. Detail of the Tumbler Gear, seen in Fig. 2, which Doubles the Number of Speeds.

changes of speed at this place, as previously mentioned. The bevel gear shown on the idler shaft in Figs. 2 and 3, transmits the movement through a vertical splined shaft to the head. From here (through a set of back gears operated by the handle seen at the front of the head) connection is made with a pinion driving a face-plate gear at the front end of the spindle. The sixteen speeds thus obtained range from 15 to 200 revolutions per minute, with a speed of 230 revolutions per minute given to the constant-speed driving shaft.

The spindle being thus driven by a geared face-plate on the side nearest the work, the capacity of the machine for doing heavy milling is greatly increased. Provision is made in the face of the spindle for bolting or otherwise fastening cutters, such as used in heavy milling work. The boring-bar feeds 27 inches, and can be arrested by a clamp bearing so that 55 inches of feed can be provided. A hand-wheel is set close to the work at a point convenient for operating and setting boring-bars. It allows the workman to be within easy reach of the cutting tool and of the hand-wheel and feed friction at the same time.

The machine has power feeds in all directions; that is, for the cross and longitudinal movements of the carriage, for the vertical movement of the head on the column, and for the longitudinal feed of the boring-bar. Nine feeds are provided, ranging from ¾ to 5½ inch feed per minute, taken from the constant-speed shaft. In connection with the spindle speed changes, this gives 144 different feeds in inches per revolution, ranging from 0.006 to 0.340. Of course all of these feeds per revolution cannot be obtained for each spindle speed.

The feed box is mounted above the speed change gear box at the right of the machine. It is controlled by levers *H* and *H*, each of which has three positions, permitting nine different combinations for the nine feeds with which the machine is provided. This mechanism controls all the feeds. It may be connected with the bar or table feed, as desired, by the manipulation of lever *C*. Connection with the feed elevating screw for vertical traverse in milling is made by operating lever *D*. This same lever shifted in the opposite direction gives a rapid movement of the slide on the column. These feeds, as well as all the other feeds and power traverse movements of the machine, are reversed by the operation of lever *E*. The power cross feed of the table is provided with an automatic stop operated by dogs seen at the right-hand side of the table in Fig. 1. The longitudinal feed of the carriage is obtained by connecting the splined feed shaft (transmitting the power to the table cross-feed screw) with the screw for the longitudinal feed of the carriage on the bed. This provision for power longitudinal feed of the carriage is an unusual one in boring machines, but it was so easily made that it was thought best to incorporate it in the design, as there may be cases in which it would prove useful.

All these adjustments can be operated for fine setting by hand as well, and it is interesting to note the way in which the adjustments and manipulating handles have been concentrated at the working end of the machine to make the operation as simple as possible. At *F* is shown the back gear controlling lever, the movement of which gives either a fast or slow speed to the spindle. This is located close to the spindle driving gear so that excessive torsion of long shafts is avoided. The hand-wheel for the rapid hand adjustment of the boring-bar is shown at *J*, with the feed friction mounted in its hub. The fine feed of the boring-bar, as well as the fine hand elevating adjustment, is effected by a crank on the end of squared shaft *K*. The carriage hand feed (which is out of the range of this engraving on the left), is controlled by another squared shaft. The belt shifter is seen at *Q*. A further point of convenience in the design of the tool is the segregation of the feed and speed mechanism in easily removable casings. The machine is to this extent constructed on the unit system. It is only necessary to remove six screws and pull out the feed and speed driving

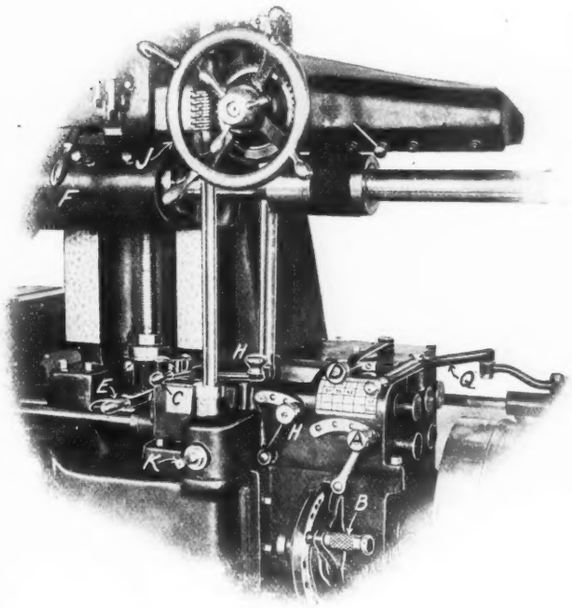


Fig. 4. View showing the Arrangement of the Controlling Handles in Locations convenient to the Operator.

shafts, to permit the removal of the respective feed and speed box from the machine.

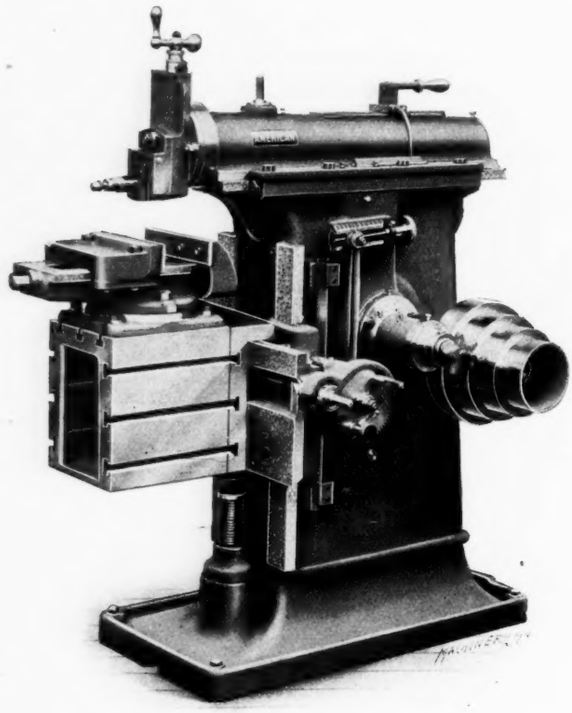
The machine is built to accurate dimensions throughout, so that the various parts are assembled without fitting in the principal dimensions. This means that a high grade of workmanship is employed, as is necessary on a machine to be used for the work for which it is designed. The weight and stiffness of the machine is also a great factor in producing accurate work. All the revolving parts such as shafts and studs are made of crucible steel and ground to size, while all bearings which have shafts running at any considerable speed are bushed with suitable bearing metal. In general, the builders have planned to make it a first-class tool in every respect, to meet the requirements for jig and fixture making, and for doing interchangeable work, as well, without the use of jigs and fixtures.

AMERICAN 15-INCH CRANK SHAPER.

Some time ago we published in MACHINERY a communication from one of our readers on the tool-room *versus* the machine-shop shaper. In this article many of the characteristic features required in each of these two classes of shapers were referred to. The distinction between a tool-room and a machine-shop shaper is becoming more and more apparent with the introduction of new machine shop methods, and it has been recognized by manufacturers of this class of tool that the ordinary shaper of the past is entirely inadequate to meet the demands of the present time. The shaper,

which in the past has often been regarded merely as a tool-room machine, has been made a manufacturing machine. In order to meet these changed conditions, the American Tool Works Co., 300-350 Culvert St., Cincinnati, Ohio, has brought out a new line of extra heavy and powerful shapers intended especially for heavy duty and designed with a view of permitting not only a high rate of production, but at the same time insuring accuracy of alignments and durability.

In order to secure the desired end, the column of the new shaper has been made wider and deeper than usual, and is



Shaper of Heavy Design brought out by the American Tool Works Co.

strongly braced internally, thereby offering proper reinforcement along the lines of the heaviest strain. The column projects both at the front and the back in order to give a long bearing for the ram, and the base is made large, so as to give proper support to the machine. The ram is thoroughly braced by internal ribs, its bearing in the column is wide, and it is provided with a continuous taper gib, having end screw adjustment for taking up the wear. The stroke of the ram is positive, and there are four rates of speed, ranging from 20 to 65 strokes per minute. The length of the stroke can be changed without stopping the machine. A pointer on the ram, traveling along an index, as shown in the illustration, shows the length of stroke at any setting. The tool-carrying head can be set at any angle within an arc of 100 degrees, and is provided with an efficient locking device. The down-slide in the head is also fitted with a continuous taper gib, having an end-screw adjustment for taking up the wear. The feed-screw is provided with a graduated dial, reading to 0.001 inch. The tool-post is made large so as to permit using holders for inserted cutters.

The table is provided with three T-slots, both on the top and on the sides, and is made of a heavy box section, ribbed on the inside to insure strength. The apron has also three T slots in its face to permit the clamping of work when the table is removed. The cross-rail is longer than usual, thereby giving the table a long horizontal range of travel. A telescopic elevating screw of large diameter is provided with ball bearings for making the elevation of the cross-rail easy. The cross-feed is of the builder's new patented design. It is variable and automatic, having a range from 0.008 inch to 0.200 inch, and can be changed while the machine is running. It is operated by the knob and screw shown on the side of the machine, by which a lever with an attached pointer is moved. The pointer indexes on a scale having 25 graduations, each graduation representing 0.008 inch feed. The construction is such that there is no necessity of change in adjustment of the feeding mechanism due to the change of position of the cross-rail. The feed gears are properly covered to prevent accidents.

The rocker arm is forked at the top, and this, together with a large opening through the column, permits a shaft of 2½ inches diameter to be passed under the ram for key-seating. Larger shafts may be key-seated by setting over the table so that the shaft passes outside of the column, the head then being set at an angle.

Throughout the design of this machine special attention has been paid to the lubrication of working parts. The ram slides are provided with felt wipers at both the front and center of the column. An oil pocket is cast integral with the column at the rear, for collecting waste oil. A large quantity of oil is stored in a pocket cast integral with the arm, and provided with suitable means of distribution for the thorough lubrication of the crank-pin and sliding block in the rocker arm. The counter-shaft has tight and loose pulleys 12 inches in diameter by 3¼ inches face, running at 180 R.P.M.

Some interesting tests have been carried out by the builders to ascertain the capacity of the machine. Cuts have been taken in cast iron ⅜ inch deep with 0.016 inch feed, 4 inches long, and ⅛ inch deep with 0.048 inch feed of the same length, with the belt on the second slow cone step. Another cut was taken in cast iron ⅛ inch deep, 0.024 inch feed, 12 inches long, with the belt on the first slow cone step. In steel, a cut was taken ⅛ inch deep, 0.016 inch feed, 2½ inches long, with the belt on the second slow cone step, and the same cut 10 inches long, with the belt on the first slow step.

SCHELLENBACH 18-INCH CONE-DRIVEN LATHE.

The accompanying illustration, Fig. 1, shows an 18-inch by 8-foot cone-driven Schellenbach engine lathe, made by the John B. Morris Foundry Co., 933 Harriet St., Cincinnati, O. This machine is of the same general design as the company's geared head lathe, involving many original and ingenious features, which was illustrated in the June issue of MACHINERY. The difference between this machine and the one

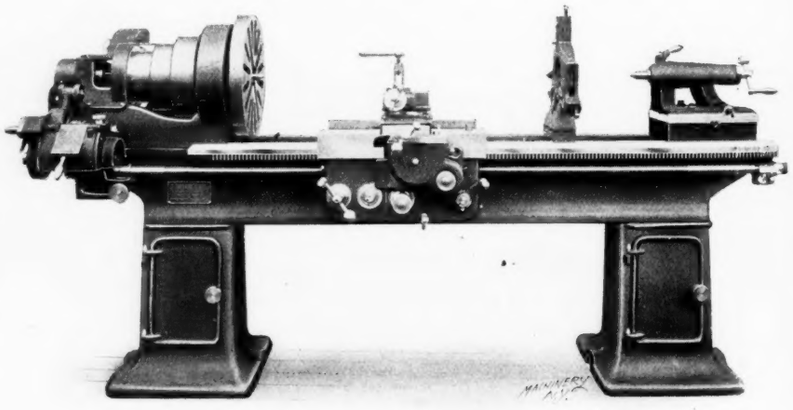


Fig. 1. Cone-driven Lathe built by John B. Morris Foundry Co.

then described consists in the matter of the drive, the present machine being cone-driven instead of having a geared head. It will, therefore, be necessary in this description only to call attention to the features involved in the design of the head, which is shown in section in Fig. 2. The driving cone is provided with three steps for a 3-inch double belt, the largest diameter of the cone being 12 inches. There are provisions for two sets of changes of speed through the back-gears, making in all nine changes of speed with a single speed counter-

shaft. However, the counter-shaft furnished with this machine is provided with double friction pulleys, and where a reverse motion is not required, it is possible to have a forward motion at two different speeds, thus giving 18 speed changes in all for the spindle of the machine. The back gears are operated in the usual manner. Special attention should be called to the very efficient manner in which the manufacturers have covered not only the back gears, but, in fact, all gearing on the machine. Not only has adequate covering been provided, but the covers have been made and attached to the machine in such a way as to present a very pleasing and harmonious appearance.

From the sectional view of the head, the arrangement of the drive can easily be studied. It will be seen that the spindle *A* has a flange at its right-hand end, where the gear *B* is doweled and screwed to it. This gear *B* is threaded internally in a recess, which receives the face-plates or the chuck. The chuck-plate *C* fits the counterbore of the chuck as indicated, is bored to fit on the end of the spindle, and is also threaded on the outside to screw into the gear *B*. It will be noticed that the flange of the spindle can thus be clamped tightly between the chuck-plate *C* and the gear *B*. This arrangement eliminates torsional strains within the spindle, when the drive is through the back gears. The overhang of the chuck from the face of the jaws to the front spindle bearing is not as great as with the ordinary type of lathe.

For the direct drive, the clutch teeth *D* formed upon the spindle engage with corresponding teeth in the clutch *E*, which is splined to a cone-pinion sleeve *G*. This clutch is operated at the back end of the head-stock by a spring-seated plunger, passing through the cone pulley. This plunger is provided with a knurled head having a pin to hold it out of engagement as shown.

The machine is provided with the quick change device described in connection with the geared head lathe, referred to above, giving a range of threads from 2 to 112. If required,

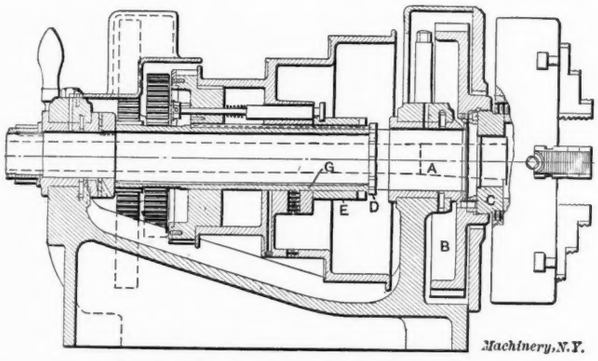
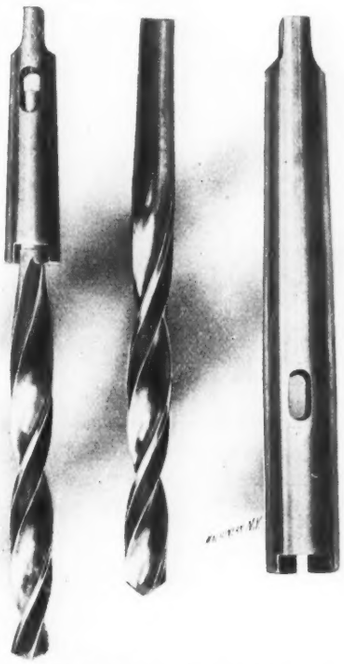


Fig. 2. Section through Head-stock of Lathe.

the machine will be provided with a plain system of change gears as well as with this quick change system. While referring back to the former description for complete details, it may be of interest to mention some of the special features of this lathe, such as the double plate apron, and an arrangement for rough-chasing threads by the ordinary rack feed, in place of the lead-screw, the object being to preserve the accuracy of the lead-screw and to use it only for thread cutting where a high degree of perfection is required. This lathe is provided with cabinet legs, having hinged doors, as indicated. Another interesting feature is that a single wrench operates every adjusting screw throughout the lathe, including the tightening of the tail-stock to the shears. This lathe is also made in 14- and 16-inch sizes.

ACME HIGH-SPEED TWIST DRILL.

The drill and its socket illustrated herewith are manufactured by the Acme Drill Co., Sherman Ave. and Runyon St., Newark, N. J. The special feature of the combination is the strong drive obtained. As may be seen, the drill is made from a twisted bar of stock of special shape, milled accurately to dimensions. The shank is left straight and untwisted. The grooves in the sides of the shank are engaged by the rounded projections on the end of the collet, which effectively prevent the tool from rotating in its socket. The outside diameter of the shank is finished on a taper and fits a corresponding taper in the collet, being thus firmly supported and centered, as with the ordinary Morse taper drive. As may be seen, there is no tang to twist off. The drill is driven from its largest diameter, and no jaws, sleeve or



A Twisted, Taper Shank Drill, with a Taper Drive.

wrench are necessary to tighten it. Owing to the method of manufacture, its cost is very low in comparison with other good high-speed drills.

The drill is made in standard sizes from $\frac{5}{8}$ inch up to 2 inches, varying by 64ths. The collets and sockets correspond with the standard Morse taper sizes, and the collets have shanks fitting in Morse taper holes.

CINCINNATI FOUR-JAW INDEPENDENT CHUCK.

In Fig. 1 is shown an exterior view, and in Fig. 2, a cross-section of an improved independent chuck manufactured by the Cincinnati Chuck Co., Spring Grove Ave. and Sassafras St., Cincinnati, O. It might seem that there would be little possibility of improvement in an appliance so nearly standardized as the independent four-jawed chuck, but the makers

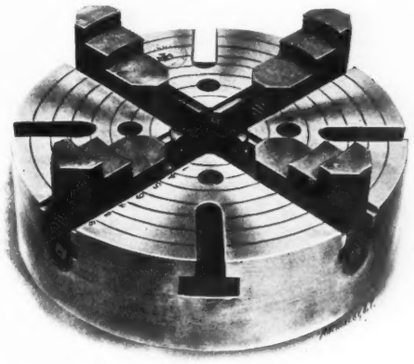


Fig. 1. An Improved Design of Independent Chuck.

have found that the tool is susceptible of improvement. In the ordinary independent chuck, the screws are mounted in semi-circular bearings, and receive the thrust on semi-circular shoulders formed in the cast-iron shell of the chuck. When these shoulders become worn in use, it is impossible to take out the play. As shown in Fig. 2, in this design, hardened bushings are provided at each end of each screw. The bearing surface and thrust surface occupy a full circle

in each case, so that, in connection with the hardened materials used, the surface should wear at least three times as long. When end play becomes noticeable, it can be taken up by a machinist in a very short time, making the chuck as good as new in this respect. These bushings hold the screws absolutely in line with the jaw, preventing any tilting

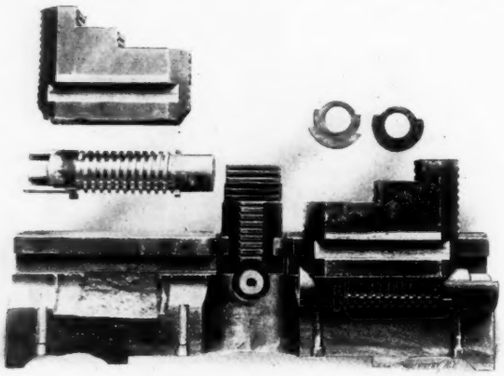


Fig. 2. Section of Cincinnati Chuck, showing Hardened Bushings for Screws.

of the screws and consequent cutting of the thread. The screws are of the highest grade of spindle steel and have their bearings carefully ground. The shell is made from the best quality of gray iron, and the jaws are reversible.

THE VEEDER SPEED INDICATOR.

The Veeder Mfg. Co., of Hartford, Conn., has recently adapted the counting mechanism used in their well-known cyclometer and odometer to the work of the speed indicator. The device rearranged for this purpose is shown in Fig. 1, and in section in Fig. 2. As shown, it consists simply in mounting the regular registering or counting mechanism in

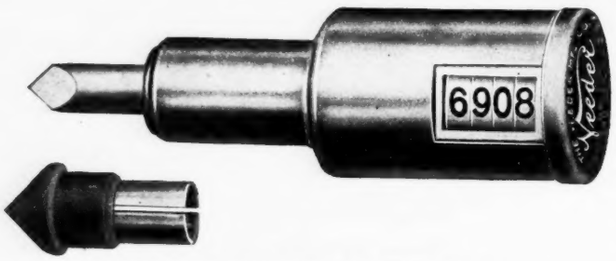


Fig. 1. The Veeder Speed Indicator or Revolution Counter.

the end of a drawn metal case, and in providing a ball bearing registering spindle and a suitable clutch for connecting it with the counter.

The point of the spindle *E* is placed against the end of the shaft whose speed it is desired to measure. This spindle, which is provided with ball thrust bearings and is seated in bushing *F*, carries on its inner end the clutch member *C*.

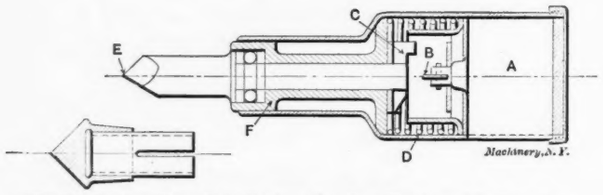


Fig. 2. Section through Indicator, showing Clutch and Ball Bearing.

Under normal conditions, spring *D* presses bushing *F* outward so that the clutch member *C* is separated from the corresponding member *B*, attached to the spindle of the recording device. When, however, *E* is placed against the shaft whose speed it is desired to measure, spring *D* is compressed, the two clutch members come in contact, and the recording mechanism is driven from the shaft. When the reading is completed, the removal of the instrument allows the spring to expand, separating *B* and *C* and stopping the revolution of the counter.

A feature of the device is the large number of revolutions provided for. The instrument registers up to 9,999 and repeats itself without requiring adjustment. This fact, and the ease with which the operation is automatically started and stopped, makes it possible to take readings without the use of the stop watch. Since readings may be taken for a long period of time even on high-speed shafts, it obviates the necessity for extreme accuracy in the timing of the interval. It is only necessary to watch the dial of the time-piece, the indicator itself requiring no attention. The difference between the readings of the counter at the beginning and end of the interval is the number of revolutions of the shaft in that time. It is essential to jot down the readings of the counter before beginning to count, because no arrangement is provided for setting it back to zero. Such a device would complicate the instrument, and it will be found much easier to take down the readings than to set back the counter. No matter in what direction the shaft runs, the difference between the readings will be the number of revolutions required.

The indicator is not affected by a magnetic field. This, in connection with the fact that the separate insulating tip shown is furnished with the instrument, makes it well adapted for use on generators and motors. It has frequently been used at as high as 5,000 revolutions per minute. It operates equally well in either direction, adding when running one way and subtracting when reversing.

CHARLES STECHER CO., 19 S. Jefferson St., Chicago, Ill. A high-speed bench drill which is built in miniature along the lines of the standard drill press, furnishing all the conveniences of the latter, including a slotted base for attaching large work. The base is cast in one piece with the countershaft frame. The drill is 10 inches swing and has a capacity for drills up to ½ inch in diameter.

JOSEPH DEMARKI, 194 Griffith St., Jersey City, N. J. Self-centering arbor which may be adjusted through a considerable range. This device is made in two sizes, one to hold from 4 to 10 inches, and the other from 10 to 20 inches. The work is gripped by a three-point bearing on each end, furnished by the sides of arms, spread outwardly by the pressure of a screw and nut.

LANDIS MACHINE CO., Waynesboro, Pa. All-steel cutter head of improved construction for holding and controlling the milled chasers used in this firm's bolt and pipe thread cutters. These chasers are made entirely of steel with the important wearing parts hardened. The head, when in closed position, is locked entirely within itself so that none of the thrust of the cutting action is taken between rubbing surfaces. Any set of chasers is adjustable for any diameter within the range of the head.

BRIDGEFORD MACHINE TOOL WORKS, Rochester, N. Y. A gap lathe intended primarily for refinishing car axle journals without removing the wheels, and for this purpose made with a very wide gap sufficient to clear car wheels of standard gage. It may also be used as a single end axle lathe. To make this possible, the head-stock is arranged so as to slide on the bed by a rack and pinion movement, to bring the wheel within the range of the carriage. It may also be equipped for refinishing engine truck axle journals, in which case an extra carriage is arranged between the wheels, leaving a short gap on each side.

CINCINNATI MILLING MACHINE CO., Cincinnati, Ohio. A new line of high-power milling machines, designed entirely from original data as to speeds, feeds, pressure of cut, etc., obtained from experiment. These machines are built on the unit system, and are so arranged that, by the interchange of various units, the machine may be arranged for constant speed or cone pulley drive (in either case with the shaft at right angles or parallel to the spindle), variable speed or a constant speed motor drive, and with the feed in inches per minute or in fractions of an inch per revolution. The same design throughout, with the exception of the spindle mechanism and the upper part of the column, is also used for the vertical spindle machine.

FINISHING BEVEL GEAR BLANKS IN THE DAVIS TURRET LATHE.

We show in the engraving a set of tools designed by the W. P. Davis Machine Co., Rochester, N. Y., for use on its turret lathe for finishing bevel gear blanks such as shown at *A*. This gear is clamped in the chuck with the hub projecting outward. The first operation consists in running the three-lipped drill *B* through the work. This roughs out the cored hole in the hub. This hole is next trued with the boring tool shown at *C*. The double-ended boring cutter at *D* is then passed through the hole, sizing it ready for the reaming. The reamer shown at *E* is mounted in a floating holder and finishes the hole to accurate size. The knee tool *F* is now brought into position and the outside of the hub is rough turned, after which it is finish turned with a similar tool *K*. All of these tools, of course, are carried by the turret. The back of the gear and the end of the hub are next faced with cross-slide tools, completing the machining of this side of the gear.

In the second operation, the turned shank of the bevel gear is held in the special chuck shown at *G*. This consists of a simple casting, bolted to the face-plate of the lathe, and having a bored hub provided with a clamp similar to that in common use for holding tool shanks in the turret of the screw machine. It is provided also, as shown, with two pins projecting from the face of the boss, which fit into corresponding

Set of Tools for use in the W. P. Davis Machine Co.'s Turret Lathe, for Finishing Bevel Gear Blank.

holes provided in the back face of the gear blank, thus preventing it from turning when heavy cuts are taken. When the blank is thus chucked, tool *H*, which is bolted to the face of the turret, is forced onto the work. This carries a pair of serrated roughing cutters which remove the scale on the beveled face of the gear. A similar pair of cutters mounted at right angles to these finish the plain inner face of the gear down to the bore. The tool is steadied while taking these heavy cuts by a pilot or guide arbor which enters the bore of the work. The tool shown at *J*, which is very similar in construction, is next brought into operation to finish these same surfaces. The finishing of the back bevel in the blank is effected by forming tools carried in the front and back cross slides, one of them being used in the roughing operation for removing the scale, while the other finishes the surface to size.

This series of two complete operations requires 15 minutes for each gear, from the rough casting to the finished blank complete. The dimensions of the finished work are: diameter of hub, 2 5/16 inches; outside diameter, 6 5/32 inches; length over all, 5 inches. The builders of this outfit make a specialty of providing their turret lathes with suitable sets of tools for rapid and accurate work on cast iron parts of varied shapes and sizes.

* * *

Remember that the world does not owe you a living, but it does owe you an opportunity to earn a living.

AN AMERICAN MECHANIC IN EUROPE—7.

A SERIES OF LETTERS FROM OSKAR KYLIN ON THE EDITORIAL STAFF OF MACHINERY.

COPENHAGEN, DENMARK, September 14, 1908.

The business conditions in the Scandinavian countries have, although slowly, continued to improve during the month of August. Judging from the reports in the trade journals and from the opinions of a few machinery dealers who have direct connections with the large trade centers in Germany and England, the conditions in these countries have improved even in a greater degree, and hopes are expressed that the crisis of the year will soon have passed entirely. The labor troubles in Sweden, which were referred to in my letter in the September issue, have been satisfactorily settled, and a return made to normal conditions in this respect.

General Conclusions regarding the European Machine Tool Trade.

The present letter will conclude the series which the writer has contributed to MACHINERY regarding European trade conditions. It may, therefore, be appropriate to here summarize some of the general conclusions reached, and emphasize the points which appear to be of the greatest importance.

If a comparison is made between the general state of development of the machine tool industry in America and the different countries which the writer has visited during the past spring and summer, it must be said that America is still holding its own, and is leading in this industry. This is true both in regard to the design of machine tools and in regard to the methods of manufacture. Without underestimating the importance of design, the methods of manufacture are, however, in the opinion of the writer, of greater importance. When meeting the competition of foreign manufacturers on foreign ground, the American makers face the disadvantage of higher per capita wages, and in order to lower the cost of manufacture per machine, systematic methods must be employed. Germany, however, has not failed to see the importance of this. The advantage of the systematic methods which can be employed in specialized manufacture are being more and more recognized. It is true that in Germany there still exist many concerns which work along in the old rut, and which have not as yet specialized in any particular line; but these firms are forced to recognize the success achieved by such manufacturers as have devoted themselves to a single line, and in order to be able to compete, the former firms must finally follow the trend of the times.

England must be considered as a close third in regard to modern machine tool manufacture. Some English makers appear to be somewhat more conservative than the German, and seem to believe in the superiority of their own methods, but this is not true of all English firms, and there are many concerns which can be favorably compared with average American firms in regard to equipment and product. With the exception of France, where the machine tool industry has not reached any large proportions, the remaining European countries are small as compared with the ones mentioned; and shut out from one another by tariff walls, they find it, as a consequence, difficult to keep step with the larger nations. Forced to largely depend upon the home market, the firms of these smaller nations cannot turn out their product in very large quantities, and are consequently, in a measure, prevented from specializing to the same extent as is possible in a large country with a large home market. These smaller nations too, however, are learning the industrial watch-word of the times, "specialization."

What has been said above with reference to the situation of the machine tool industry in the different countries is, of course, true only in a general way. It must be understood that there are to be found concerns of the very highest standard in any country, no matter what its size is. These concerns have, so to speak, broken away from the peculiarities that belong to the different nations, and have become more or less international in the manner in which they are managed.

It must be considered an undeniable proof of the superiority of the design of American machine tools that they are so frequently copied abroad, sometimes even by firms having a

reputation of their own. Germany appears to be the hot-bed of this copying, but it is by no means confined to that country. The writer found evidences of such copying in a large number of places, all the way from Italy to Sweden. It should be understood, however, that it is not only American machines that are subject to imitation, but all good designs, of whatever origin, are imitated in a degree corresponding to the quality of the design and the usefulness of the machine. This same system of imitation, of course, also takes place in America, one manufacturer imitating the successful design of another. This imitation in a sense, is deplorable, because it very often prevents a concern which has expended a great deal of capital and energy in the development of a machine of high standard from reaping its due profit, and it is difficult to find a remedy outside of the protection afforded by patent laws.

In my previous letters I have pointed out, from time to time, that many American machine tools are, in some respects, too weak for European conditions and material, and opinions to this effect expressed by European machine tool users have been quoted. Although it is true that, generally speaking, the American design is weaker than the European one, it seems, however, as if some of the persons interviewed had exaggerated the matter. Although it cannot be denied that when used on very heavy work and hard material, as used in Europe, American machine tools are often too weak to stand the strain, it may sometimes be that the machines have been put to uses for which they were not intended. No matter to what extent the criticism is unjustified, however, the American manufacturer should not permit it to pass by unnoticed, because many European users believe that the American machine tools are too weak, and even if their ideas are erroneous, whatever can be done to prevent such an opinion from working an injury to American export trade ought to be done.

It should once more be emphasized in connection with this that American manufacturers who really want any European market should not neglect to thoroughly study the conditions of the machine industry over here. Many conditions here influence the American machine tool trade which appear to be comparatively unknown in America; the European industries are making rapid progress, and the situation of a dozen years ago is changing by leaps and bounds, and it is surely necessary for American machine exporters to keep posted in order to know how to handle the trade properly.

It has been pointed out to the writer by a few machine tool users that there is a tendency of the modern machine tool designer to make the machines too complicated. It has been claimed that there are features on the machines which are but very rarely used, and when the time required for placing the attachments in proper position on the machine is considered, it often eliminates any saving in time from their use. There may, of course, be several reasons for this claim. Sometimes the user himself may be at fault because of having bought the wrong machine for his needs; sometimes the operator may be inexperienced in the use of an attachment which is but seldom required, and spend an unnecessarily long time in its adjustment. At any rate, there is apparently some truth at the bottom of a matter so often pointed out. The criticism seems to particularly refer to the universal machines in which the designer attempts to have the machine accomplish almost anything, thereby making it too complicated, and consequently too expensive. When buying such a machine, the user often has to pay for some feature which he will never need.

In an open market, Europe, of course, has, if it employs modern manufacturing methods, still an advantage in the somewhat lower wages that are paid here, but the general tendency in the European countries is for a decided increase in wages, and it may be that, before many years, about the same level in wages will be reached in Europe as prevails in America. This will eliminate one of the arguments used by the advocates of a protective tariff, and might perhaps lead to a reduction in tariff duties between the various industrial countries of the world. This would mean a larger market for the manufacturers of machine tools, and leave room for a still greater degree of specialization than that of the present day, thereby making possible a better utilization of human labor, natural resources, and capital.

OBITUARY.

Lyman M. Starrett, one of the builders of the *Monitor*, and the oldest printing press pattern-maker in America, died at his home in Brooklyn Manor, Long Island, September 15, aged seventy-five years. For sixty years he had been an employe of R. H. Hoe & Co., New York. He was the inventor of the first street sweeper drawn by horses, and of a number of other valuable devices.

Gardner D. Hiscox, the author of several well-known books on technical subjects, died at his home in East Orange, N. J., September 13, aged eighty-six years. Mr. Hiscox was the author and compiler of "Mechanical Movements, Powers and Devices," "Compressed Air: Its Production, Use and Applications"; "Horseless Vehicles, Automobiles and Motor Cycles"; "Modern Steam Engineering"; "Hydraulic Engineering," etc. Although a prolific writer and a man of considerable repute as authority on mechanical subjects, Mr. Hiscox was not a college graduate, having had a common school education only. His wife, three sons and a daughter survive him.

Dr. Theodor Peters, President Verein deutscher Ingenieure (Society of German Engineers) died in Berlin, September 2, 1908. Dr. Peters had devoted all his time and energy to the interests of the society for more than 25 years, and the important position which the society to-day occupies among the leading engineering associations of the world was largely due to his untiring efforts. He was particularly interested in the publication of the *Technolexikon*. At the present time it seems as if this stupendous undertaking would be carried to a successful completion, although it was not permitted one of its ablest and most enthusiastic supporters to see the work finished.

Edward B. Pike, president of the Pike Mfg. Co., Pike, N. H., died at his home, August 24, following an operation for appendicitis, aged sixty-three years. He was salesman for the Enterprise Mfg. Co., Philadelphia, beginning in its employ some time in the early 70's, and finally becoming head salesman. His health becoming impaired, he associated with his brother, A. F. Pike, in the scythe-stone and oil-stone business in 1878, and in 1884 the A. F. Pike Mfg. Co. was organized with A. F. Pike president and E. B. Pike vice-president. The brother died in 1891 and E. B. Pike became president. The business was rapidly developed under Mr. Pike's management, and is one of the best known in the sharpening stone trade.

* * *

PERSONAL.

H. M. Lucas, president of the Lucas Machine Tool Co., Cleveland, Ohio, sailed for Europe, September 5, for a business trip in the interest of his company.

Henry C. Karlson has opened an office at 39 Cortlandt St., New York, where he will act as solicitor of patents and as designer of automatic and special machinery.

H. L. Mills, formerly of the sales department of the Whiting Foundry Equipment Co., has resigned to become president of the American Specialty Co., 1440 Monadnock Blk., Chicago, Ill. This company is marketing the "Use-Em-Up" drill socket.

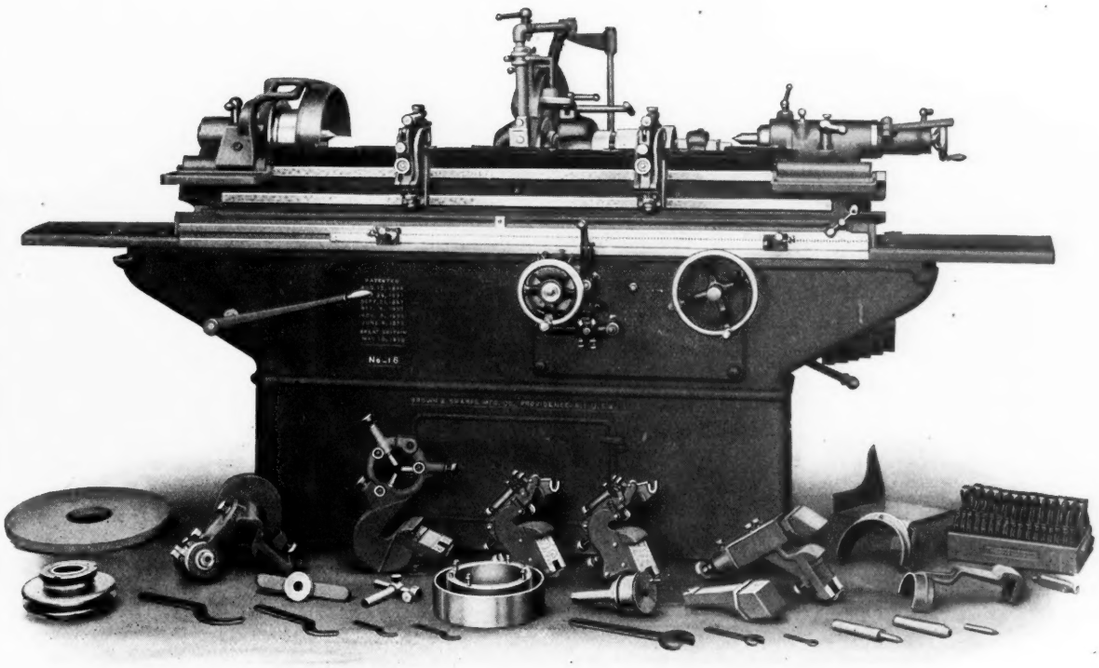
W. B. Gardiner, for the past ten years employed in the model department of the Winchester Repeating Arms Co., New Haven, Conn., has been appointed superintendent of the manufacture of the Smith one-lock adjustable reamers, made by the Wm. J. Smith Co., New Haven.

Richard Froboese, recently mechanical engineer of the Imperial Gas Engine Co., San Francisco, Cal., has engaged in business for himself as consulting engineer in all matters pertaining to gas power. Mr. Froboese, who is a graduate of Braunschwig, Germany, will have an office at 507 Mission St., San Francisco. His experience in the past eight years was with the Power & Mining Machinery Co., Milwaukee, and the Union Gas Engine Co., and the Hercules Gas Engine Co., of San Francisco. He designed the present types of engines now

Brown & Sharpe Mfg. Company

PROVIDENCE, RHODE ISLAND, U. S. A.

Not only is a B. & S. Grinding Machine Accurate when you start it but its Accuracy is Durable.



The importance of this point cannot be overestimated in that the Grinding Machine you want is the one that will wear well.

And nothing contributes so much toward the attainment of lasting accuracy as emphasis on Quality of Workmanship.

Sufficient weight that vibration may be eliminated as far as possible, each part in right relation to the whole, and correct alignments insisted upon, are all factors that establish accuracy as a permanent feature in B. & S. Grinding Machines.

A CIRCULAR OF ANY OF THE B. & S. GRINDING MACHINES SENT TO ANY ADDRESS.

being built by the latter company, and it is his intention to specialize along this line as consulting engineer.

C. L. de Muralt has been reappointed professor of electrical engineering at the University of Michigan for the coming year. Prof. Muralt will devote his attention during the winter semester to the consideration of the general aspects of applied electricity. The course of lectures will include discussion of the characteristics and application of electricity and continuous current motors; the design, construction and operation of electric plants; the principles and methods of transmitting, distributing and controlling alternating currents; the calculation and operation of electric railways; and the commercial management of electric properties and interests.

* * *

COMING EVENTS.

October 12-16.—American Street and Interurban Railway Engineering Association convention at Atlantic City. Office of the Secretary-Treasurer, Engineering Societies Building, 29 West 39th St., New York.

October 13.—The season of professional meetings of the American Society of Mechanical Engineers will be opened in October by a meeting of the Gas Power Section, in the Engineering Societies Building at 29 West 39th St., New York. Mr. H. L. Doherty, chairman of the Meetings Committee of the section, will present a report for discussion, outlining plans for future work, and there will also be a discussion of standards to be used in gas power work. Two papers will be read, one by E. A. Harvey on gas-producer plants, with data upon costs, performance, etc.; and one by N. T. Harrington giving the results of tests to determine the loss of fuel weight in a freshly charged producer, due to increase of ash contents in the fuel bed. The first paper will be illustrated by lantern slides, showing actual plants and plans for the arrangement of apparatus.

October 13-15.—Annual meeting of the Railway Signal Association at Washington, D. C. C. C. Rosenberg, 12 North Linden St., Bethlehem, Pa., secretary.

October 13-15.—Annual meeting of Federation of Trade Press Associations, at Chicago, Ill. Morton Hiscox, secretary, 1431 Monadnock Block, Chicago, Ill.

October 20-21.—Annual convention of the National Machine Tool Builders' Association at the Hotel Imperial, corner of Broadway and 32d St., New York. P. E. Montanus, Springfield Machine Tool Co., Springfield, Ohio, secretary.

October 22.—MACHINERY's annual outing.

November 19-21.—Annual meeting of the National Society for the Promotion of Industrial Education, Atlanta, Ga. James P. Haney, 546 Fifth Ave., New York, secretary.

December 1-4.—Annual convention of the American Society of Mechanical Engineers. Engineering Societies Building, 29 West 39th St., New York City. C. W. Rice, 29 W. 39th St., New York, secretary.

December 31-January 7.—Ninth annual show of the American Motor Car Manufacturers' Association at Grand Central Palace, New York City.

January 16-23.—Ninth annual show of the Association of Licensed Automobile Manufacturers at Madison Square Garden, New York.

NEW BOOKS AND PAMPHLETS.

WIRELESS TELEGRAPHY AND TELEPHONY. By Walter W. Massie and Charles R. Underhill. 76 pages, 4¾ x 7¼ inches. 28 illustrations. Published by D. Van Nostrand Co., 23 Murray St., New York. Price $1.00.

This work describes in simple manner the nature of ether waves and the apparatus used in wireless telegraphy and telephony. It is explained that the ether waves employed in wireless telephony differ from light waves, principally in the length of the wave. Light waves range from 1/64,000 inch for extreme violet to 1/33,000 inch for extreme red, while the waves employed in wireless telegraphy vary in length from 650 feet to nearly 2 miles. The work will be found valuable by those who desire a non-technical description of the art.

A PROPER DISTRIBUTION OF EXPENSE BURDEN. By A. Hamilton Church. 116 pages, 5 x 7½ inches. Published by the *Engineering Magazine*, New York. Price $1.00.

The book is made up of a series of articles originally published in the *Engineering Magazine*. The author has given much attention to the correct distribution of the expense burden, which, as everyone knows, is one of the difficult problems in accurate cost accounting. It treats of interlocking general charges with piece costs; distributing expense to individual jobs; the scientific machine rate and the supplementary rate; classification and dissection of shop charges; mass production and new machine rate; and the apportionment of office and selling expenses.

MANUAL FOR ENGINEERS. Compiled by Charles E. Ferris. 162 pages, 2¾ x 5½ inches. Published by the University Press, Knoxville, Tenn. Price 50 cents.

This popular compilation of tables and other data has passed into the eleventh edition. The last edition contains new and valuable matter, including a carefully arranged four-place logarithm table. A four-place logarithm table answers for many arithmetical problems in engineering work, as well as the more cumbersome tables of five, six, or more places. The work was originally compiled to bring before the minds of business men and manufacturers, the strongest possible argument in favor of technical education, giving, as it were, an object lesson of the vast fund of technical data available to those interested in mechanical work.

INTERNAL COMBUSTION ENGINES. By Rolla C. Carpenter and H. Diederichs. 597 pages, 6 x 9 inches. Illustrated. Published by the D. Van Nostrand Co., 23 Murray St., New York. Price $5.00.

The aim of the author in the preparation of this work was to present in as simple terms as possible the fundamental and theoretical principles, relating to internal combustion engines, and to describe the various methods of applying these principles to the practical construction. The contents of the work by chapters are as follows: Introduction. Definitions and Classification. Indicated and Brake Horse-Power; Thermodynamics of the Gas Engine; Theoretical Comparison of Various Types of Internal Combustion Engines; The Various Events of the Constant-Volume and Constant-Pressure Cycle as Modified by Practical Conditions; The Temperature Entropy Diagram Applied to the Gas Engine; Combustion; Gas-Engine Fuels—the Solid Fuels, Gas Producers; The Gas-Engine Fuels—Carbureters and Vaporizers; Gas-Engine Fuels—The Fuel Mixture, Explosibility, Pressure and Temperature; The History of the Gas Engine; Modern Types of Internal Combustion Engines; Gas-Engine Auxiliaries, Ignition, Mufflers and Starting Apparatus; Regulation of Internal Combustion Engines; The Estimation of Power of Gas Engines; Methods of Testing Internal Combustion Engines; The Performance of Gas Engines and Gas Producers; Cost of Installation and of Operation.

CATALOGUES AND CIRCULARS.

MORSE, WILLIAMS & CO., Philadelphia, Pa. Catalogue No. 4 on Hindley worm gears and Hindley spirals. The catalogue is illustrated with examples of Hindley gearing used in pump drives, windlasses, turret turning apparatus, etc.

ROCKWELL FURNACE CO., 26 Cortlandt St., New York. Catalogue of portable heaters and melting furnace for melting all metals, tinning, galvanizing, tool hardening and all operations requiring molten metal or other heated baths.

C. H. A. DISSENGER & BRO., Wrightsville, Pa. Catalogue A of Capital gas and gasoline engines, made in sizes from 2½ to 200 horse-power; also catalogue B of Capital gasoline traction engines, built in sizes from 16 horse-power to 80 horse-power.

THOMPSON GRINDER CO., Springfield, Ohio. Catalogue of Thompson universal grinding machine, showing the grinder converted into a plain grinder, a surface grinder, a die grinder, a knife grinder, an internal grinder, a cutter grinder, a high-speed grinder, etc.

LUFKIN RULE CO., Saginaw, Mich. Catalogue No. 48 on measuring tapes and rules of every description. The list includes steel tapes, bronze tapes, surveyors' chain tapes, pocket steel tapes, pocket linen tapes, metallic warp tapes, steel rules, steel shrink rules, tinners and circumference rules, etc.

LUMEN BEARING CO., Buffalo, N. Y. Booklet advertising Lumen bronze die castings, which are made with such accuracy that no machining is required. They are particularly adapted to the construction of typewriters, adding machines, telephone parts, and all small interchangeable machinery parts made in large quantities.

GENERAL ELECTRIC CO., Schenectady, N. Y. Pamphlet entitled "Transformer Steel," giving a brief account of the material used in transformer construction, and calling attention to the company's improved type H transformer in which the described steel is used. In writing for this pamphlet, designate it as No. 3687.

GEM MFG. CO., 3253 Spruce St., Pittsburg, Pa. Catalogue of brass and steel oilers showing the old line of oilers manufactured by the company, and a new line just put on the market. The catalogue includes specialties such as foundry chaplets, inspectors' and locomotive torches, brass alcohol lamps, flexible shafts, portable drilling and grinding attachments, breast drills, universal joints, scratch brushes, etc.

DAYTON MACHINE AND TOOL WORKS, Dayton, Ohio. Catalogue No. 2 for grinding machines designed for tool grinding and manufacturing. These grinders are manufactured in three sizes, and are designated as plain cutter and reamer guide grinder, universal cutter and tool grinder No. 1, universal cutter and tool grinder No. 2, which latter can be converted into a shaft and internal grinder or a surface grinder.

WINKLEY CO., 866 Warren Ave., W., Detroit, Mich. Catalogue of oiling devices. The Winkley Co. brought out the first oil hole covers as a substitute for open oil-holes, loose plugs, screws, etc., in 1892. The catalogue illustrates a variety of styles that have been developed, suitable for all classes of machinery. These include the self-closing and the hand-closing types. A line of grease cups has been added and specialties such as brass dowel pins for patterns and special brass work to order.

TRIMONT MFG. CO., 55 to 71 Amory St., Roxbury, Mass. Catalogue of "Trimo" tools, which include the "Trimo" pipe wrench, the "Trimo" chain wrench, "Trimo" pipe cutter, "Trimo monkey-wrench," "Trimo" giant chain pipe wrench, "Trimo" special narrow jaw wrench, "Trimo" basin wrench for plumbers, etc. The company has issued a new edition of "Facts are Stubborn Things," being an account of mechanical tests made with the United States testing machine at Watertown Arsenal, Mass., to determine the strength of various makes of monkey-wrenches.

HENDEY MACHINE CO., Torrington, Conn. Catalogue of engine lathes. The construction of the 20- and 24-inch geared-head lathe is illustrated. The geared-head lathes are built in 12-, 14-, 16-, 18-, 20- and 24-inch sizes, and this type of lathe is illustrated with both motor and belt drive. The line of cone pulley lathes with reinforcing tie-bar between the spindle bearings is illustrated in detail. Lathe attachments are illustrated for relieving cutters, turning tapers, turning balls, tool-room equipment, etc. The catalogue is one of the most interesting issued by any machine tool builder.

RAHN-CARPENTER CO., 2935-2941 Spring Grove Ave., Cincinnati, Ohio. Catalogue No. 7 of engine, turret and gap lathes, built in 16 inches to 32 inches swing. The catalogue is beautifully illustrated, and besides showing the various sizes of lathes, attachments, and accessories, it illustrates the method of crating lathes for domestic and foreign shipment. The latter consideration is very important, as many American tools have received a "black eye" because of the careless and unsafe crating and protection given to the finished parts. The method of crating illustrated insures a machine being received in good condition if subjected to the ordinary rough handling that goods receive in ocean transport.

HAMMACHER, SCHLEMMER & CO., 4th Ave. and 13th St., New York. Catalogue No. 355 of tools for all trades, and supplies. The catalogue contains 1,200 pages 5¼ x 7¼ inches, of which 28 pages are devoted to the index alone. This fact gives an idea of the great number of tools and supplies listed. The catalogue lists tools for the machinist, carpenter, cabinet maker, piano tuner, die-sinker, toolmaker, mill-wright, electrician, lumberman, engineer, draftsman, upholsterer, tailor, painter, paper-hanger, molder, brick-layer, cement-layer, etc., and general supplies for manufacturers. It is one of the most complete catalogues of tools and supplies for manufacturers ever issued by any company of dealers, and is a credit to the concern represented. On account of the high cost per copy, the catalogue cannot be distributed free, except to purchasing agents, and those in position to influence the purchases of manufacturing concerns. Others desiring a copy can obtain same for $1, which sum will be credited on the first order amounting to $10.

MANUFACTURERS NOTES.

W. J. SMITH CO., New Haven, Conn., has appointed Fred Ward & Son, Inc., First and Howard Sts., San Francisco, Cal., the Pacific Coast agents for the sale of Smith one-lock adjustable reamers.

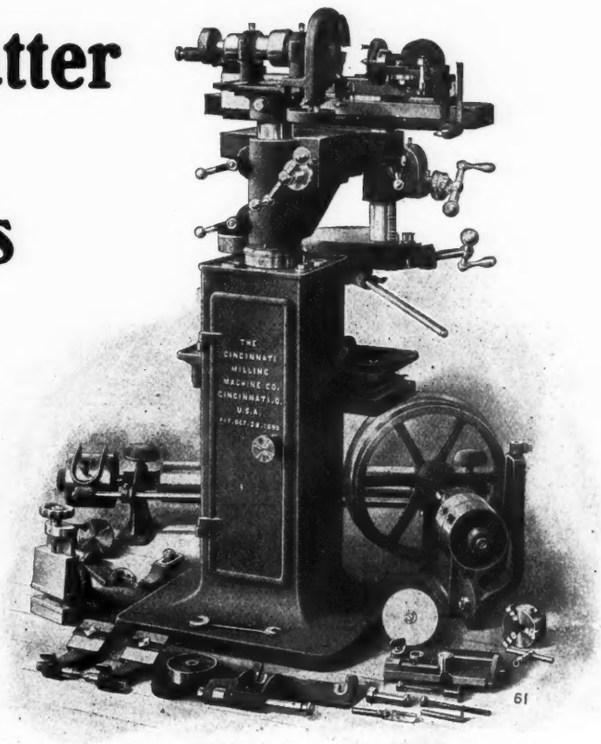
B. P. FORTIN TOOL CO., Woonsocket, R. I., recently sold, through its agency, the Prentiss Supply Co. of Boston, a No. 2 and a No. 8 universal jig to the United States Government Torpedo Station, at Newport, R. I.

CROCKER-WHEELER CO. has opened a new office in the Gumbel Building, Kansas City, Mo., for the sale of the Crocker-Wheeler motors, dynamos, transformers, switch-boards, etc. The office is in charge of Mr. A. W. Paine.

LYON METALLIC MFG. CO., Aurora, Ill., has just completed a large addition to its factory, and is now operating with double the old number of employes. The concern manufactures a complete line of factory equipment, making a specialty of unit shop racks, tote boxes, barrels, office and shop lockers, gear boxes, etc.

NATIONAL BATTERY CO., Buffalo, N. Y., announces that the receivership under which it has been operating since last February was terminated August 19, and that all claims against it have been settled. Full control of the reorganized company has been secured by the Cutler-Hammer Mfg. Co., Milwaukee, Wis., but the plant of the

Cincinnati Cutter Grinder Improvements



Taper Gib for adjusting slide.

More substantial stop dogs with fine adjustment.

Stiffer knee.

A Few Important Features:

Knee swings about column to any angle,

and table swivels about fixed centre on slide bringing work into any desired position to emery wheels.

Graduated Dials

on all swivels and adjustments.

A Quick Lever Feed

for sharpening cutters and also a slow screw feed for other work. Uses **cup-shaped wheel** for sharpening cutters.

Has Micrometer Elevating Device

for setting cutters or reamers for desired clearance—and on this depends the successful working of these tools.

Some Things it Will Do:

It will sharpen all manner and shapes of cutters, reamers, etc. Will do internal, cylindrical, surface, angular and face grinding.

It Will Save You Money,

because it will sharpen cutters, reamers, etc., correctly and quicker than any other similar tool. It is simple and convenient to operate. Any boy can run it.

Ask for Treatise giving details of Machine and its Operation.

THE CINCINNATI MILLING MACHINE CO.

Cincinnati, Ohio, U. S. A.

European Agents—Schuchardt & Schutte, Berlin, Vienna, Stockholm, St. Petersburg Copenhagen and Budapest. Alfred H. Schutte, Cologne, Brussels, Liege, Milan, Paris, Turin, Barcelona and Bilbao. Charles Churchill & Co., London, Birmingham, Manchester, Newcastle-on-Tyne and Glasgow.
Canada Agent—H. W. Petrie. Ltd., Toronto, Montreal and Vancouver.
Australian Agents—Thos. McPherson & Son, Melbourne.

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National Battery Co. will remain at Buffalo, where it will be conducted under new management and with ample capital.

AMERICAN SPECIALTY CO., formerly of Harvey, Ill., now has its office in Room 1440, Monadnock Block, Chicago, Ill. The company manufactures the "Use-Em-Up" sockets for drills and reamers which have suffered twisted tangs or broken shanks. Twisted tang drills can be used in these sockets by simply grinding flats on the side of the shanks. The company has recently been reorganized with largely increased facilities and capital.

EBERHARDT BROS. MACHINE CO., 66 Union St., Newark, N. J., has changed its corporate name to the Newark Gear Cutting Machine Co. The personnel of the company will remain the same as at present, the officers being Henry E. Eberhardt, president; H. J. Eberhardt, secretary; Elmer G. Eberhardt, vice-president, and Frank E. Eberhardt, treasurer. The new name will more properly identify the product of the company, which is exclusively the design and manufacture of gear-cutting machines and gear cutting. During the past year a number of machine tools has been added to the equipment, and the facilities of the gear-cutting department have been increased.

WALCOTT & WOOD MACHINE TOOL CO., Jackson, Mich., manufacturer of shapers, rack-cutters and lathes, is building a new factory and office structure which will be finished and in operation about January 1, 1909. The building is 70 x 150 feet, and is constructed of extra heavy material. The plan is to make a large addition later on. Mr. C. C. Wood, president, has had exceptional experience as a builder and designer of machine tools, and this fact, together with his wide acquaintance, has enabled him to greatly increase the company's business.

KELLY TOOL CO., Cleveland, Ohio, reports that the heavy body cylinder reamers made by the company are attracting the attention of engine builders because of the possibility of producing large cylinders reamed perfectly true and accurate with them. It is claimed that these reamers produce more satisfactory results on cylinder work than can be obtained by grinding or boring. They are made to fit a 5/8 x 2 5/8-inch slot in boring bars, and are equipped with 3/8 x 3/4-inch adjustable high-speed cutters. The company reports a large demand for these reamers during July and August, a fact that in view of the present business depression shows their value for general all-around purposes.

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MISCELLANEOUS.

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